TECHNOLOGY TRENDS ASSESSMENT

ISO/TTA 1

First edition
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Advanced technical ceramics — Unified classification system

Céramiques avancées — Système de classification unifiée

ISO

VAMAS

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Cover:

Photograph of a 0,2 mm × 0,2 mm square single crystal of the high temperature superconductor $YBa_2Cu_3O_{7-x}$ showing the orthogonal twin structure characteristic of this material.

Photograph courtesy of Frank W. Gayle, Debra L. Kaiser and Leonard C. Smith, Materials Science and Engineering Laboratory, National Institute of Standards and Technology.

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Foreword

ISO (the International Organization for Standardization) is a worldwide federation of national standards bodies (ISO member bodies). The work of preparing International Standards is normally carried out through ISO technical committees. Each member body interested in a subject for which a technical committee has been established has the right to be represented on that committee. International organizations, governmental and non-governmental, in liaison with ISO, also take part in the work. ISO collaborates closely with the International Electrotechnical Commission (IEC) on all matters of electrotechnical standardization.

To respond to the need for global collaboration on standardization questions at early stages of technological innovation, the ISO Council, following recommendations of the ISO/IEC Presidents' Advisory Board on Technological Trends, decided to establish a new series of ISO publications named "**Technology Trends Assessments**" (**ISO/TTA**). These publications are the results of either direct cooperation with prestandardization organizations or ad hoc workshops of experts concerned with standardization needs and trends in emerging fields.

Technology Trends Assessments are thus the result of prestandardization work or research. As a condition of publication by ISO, ISO/TTAs shall not conflict with existing International Standards or draft International Standards (DIS), but shall contain information that would normally form the basis of standardization. ISO has decided to publish such documents to promote the harmonization of the objectives of ongoing prestandardization work with those of new initiatives in the Research and Development environment. It is intended that these publications will contribute towards rationalization of technological choice prior to market entry.

This Technology Trends Assessment, ISO/TTA 1, has been developed by the Versailles Project on Advanced Materials and Standards (VAMAS) (see [1] and [2] for further information on this organization) and is published under a Memorandum of Understanding concluded between ISO and VAMAS. It reports the results of the Technical Working Area (TWA) 14 of VAMAS, which had the task of proposing a classification of advanced technical ceramics and which retains the responsibility for the technical content of this ISO/TTA. Users of this ISO/TTA who would like information on the research project should refer to the full report of VAMAS TWA 14 [3] which was prepared under the leadership of Dr S. Schneider, Jr., from NIST, Gaithersburg, Maryland 20899-0001, USA. The ISO Technical Board approved the publication of this classification as an ISO/TTA in August 1993.

Whilst ISO/TTAs are not standards, it is hoped that they will be used as a basis for standards development in future national and international standardization processes. In the particular case of ISO/TTA 1, the publication has been brought to the attention of Technical Committee ISO/TC 206, *Fine ceramics,* for use in its standardization work.

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EXECUTIVE SUMMARY

As a consequence of modern day technology needs, materials technologies have seen a waning of commodity materials usage in parallel with a commensurate increased demand for engineered materials that perform totally new functions or old functions in much better ways. Accordingly, a wave of new products using advanced materials are appearing with regularity on the marketplace. Among these new materials types, advanced ceramics have emerged as a premier class that has enabled current technologies to be improved, and new technologies possible.

Advanced ceramics currently are market entities and have been for many years. With more in the offing, estimates place world markets to be tens of billions of dollars by year 2000. Even so, advanced ceramics have not been generally recognized as a separate materials class, distinct from other types of ceramic materials. Currently standardization systems are out of date and must be adjusted to factor in a coherent way, advanced ceramics and other new material products along with the more traditional materials. Otherwise every facet of science and technology and associated parts of the economy, from the individual researchers and consumers, to manufacturers, to whole industries, to the financial community, to governments and nations, will devise their own set of advanced ceramic definitions, append various labels and develop tabulation specifications that more often than not, conflict one to another. This discordant process is already underway.

The standardization issue is complex, but one obvious first need is the development of a classification system for advanced ceramics products that defines what they are, what they are good for, and when statistics or other data are compiled, tells the level of associated activity, element by element. In recognition of this need, the Versailles Project on Advanced Materials and Standards (VAMAS) in 1988 established a new project, Technical Work Area, Number 14 (TWA 14) on the classification of advanced ceramics to provide the pre-standards foundation and building block guide for an internationally acceptable system. Three strategic objectives of TWA 14 set the directions of the international effort:

1. To identify and assess the issues inherent in developing a classification system for advanced ceramics;

2. To establish a classification structure suitable for international use in a compendium of ways, including industrial economic statistical indicators,

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materials and property databases, and products, standards and literature categorizations; and,

3. To develop mechanisms and international institutional links for system implementation.

The objectives were achieved through a work plan that included: an assessment of existing classifications systems and terminology; a worldwide survey of the classification practices and preferences of industry; and, an international workshop to develop a detailed technical basis for the preferred industrial scheme. These, and associated work activities culminated in the development of a full range classification system for advanced technical ceramics, having the following features:

- Defines "advanced technical ceramics" for classification purposes as "a highly engineered, high performance, predominately non-metallic, inorganic, ceramic material having specific functional attributes". This definition encompasses a diverse range of materials and product classes separated along physical applications like mechanical, thermal, electrical, etc., but excludes commodity products, such as building materials and refractories.

- Identifies and lists 500 different product types as advanced technical ceramics;

- Establishes a comprehensive classification system for advanced technical ceramics that is capable of expansion to accommodate new products or the inclusion of other ceramic classes;

- Provides a non-hierarchical, matrix-type scheme of classification that is accessible by a number of entry and retrieval routes to build relational databases; and,

- Provides a machine readable coding system built upon four independent descriptor fields and corresponding subdivisions that may be sequenced in any order to match the users preference. Each descriptor field is separately identified by a unique initial code letter:

  A for application,
  C for chemical character and product form,
  P for processing and
  D for property data.

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The unique code letters act as field separators in long coding strings. Detailed listings are provided for complete coding by subdivision categories of each of the independent descriptor fields.

Overall the utility of the classification system is multi-fold. Its use is advantageous at the company level for purposes involving assembly of design and materials property databases, or tabulation of inventories, or invoicing. Industry can use the system for gathering and sorting trend data on market behavior or R&D expenditures, or for literature categorization. At the government level, the system can be used for gathering national and international economic data, or other vital statistics, or for determining demographics of the field.

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RESUME

Les besoins de la technologie moderne ont entraîné une diminution de l'usage des matériaux de commodités et parallèlement, une augmentation de la demande pour des matériaux de spécialités capables d'assurer des fonctions complètement nouvelles ou de remplir des fonctions traditionnelles d'une manière beaucoup plus efficace. Ainsi, de nouveaux produits utilisant ces matériaux avancés apparaissent régulièrement sur le marché. Parmi ces classes de nouveaux matériaux, les céramiques avancées se signalent comme la première génération qui a permis l'amélioration des technologies actuelles et l'émergence de nouvelles technologies.

Les céramiques avancées sont devenus des produits industriels et ce depuis plusieurs années. Les estimations placent le marché mondial de ces produits à plusieurs milliards de dollars à l'horizon de l'an 2000, et ce n'est qu'un début ! Malgré cela, les céramiques avancées n'ont pas été généralement reconnues comme constituant une classe à part de matériaux, distincte des autres types de matériaux céramiques. A l'heure actuelle, les systèmes de normalisation sont périmés et doivent être refondus pour classer d'une manière cohérente les céramiques avancées et d'autres nouveaux matériaux ainsi que des matériaux plus traditionnels. Si cette tâche n'est pas menée à bien, chaque domaine de la science et de technologie et les acteurs économiques qui lui sont associés, des chercheurs et des consommateurs aux producteurs en passant par l'industrie toute entière, la communauté financière, les gouvernements et les états, tous vont mettre sur pied leur propre dictionnaire des céramiques avancées, donner des noms variés et des spécifications de codage qui trop souvent entreront en conflit l'une avec l'autre. Ce processus dit de la "Tour de Babel" a déjà commencé.

Le problème de la standardisation est complexe, mais l'un des premiers et des plus évidents besoins est le développement d'un système de classification pour les céramiques avancées qui définit ce qu'elles sont ; à quoi elles sont bonnes ; et quand des statistiques ou d'autres données auront été rassemblées, donnera le niveau d'activité qui leur est associé, élément par élément. Prenant conscience de ce besoin, le projet "Versailles Avanced Materials and Standards (VAMAS)", créa en 1988 une nouvelle commission "Technical Work Area" numéro 14 (TWA 14) sur la classification des céramiques avancées pour jeter les bases d'une pré-standardisation et rédiger un guide des éléments constitutifs d'un système de classification acceptable à l'échelon international. Les 3 objectifs stratégiques du TWA 14 montrent bien les axes de l'effort international :

1. Identifier et évaluer les problèmes inhérents à la création d'un système de classification des céramiques avancées.

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2. Etablir un schéma de classification permettant un usage international, pour des usages diversifiés tels que : des bases de données économiques et industrielles ; des tables des matériaux des produits existants et de leurs propriétés ; un classement des standards et de la littérature scientifique ; etc...

3. Développer les mécanismes et les liens institutionnels internationaux nécessaires à l'épanouissement du système.

Ces objectifs furent atteints grâce à un plan de travail qui inclut une évaluation des systèmes de classification et des terminologies existantes et une recherche mondiale des pratiques en matière de classification et des préférences de l'industrie, suivie d'un séminaire international pour mettre sur pied les bases techniques détaillées du schéma ayant la préférence des industriels. De tout cela et du travail qui lui a été associé émergea un système de classification complet des céramiques avancées ayant les caractéristiques suivantes :

- Il définit pour les besoins de la classification les "céramiques avancées" comme des "matériaux céramiques, de conception évoluée, à hautes performances, inorganiques à dominante non métallique et présentant des attributs fonctionnels spécifiques". Cette définition englobe des types de matériaux et de produits assez divers qui sont classés selon leurs applications physiques comme la mécanique, la thermique, l'industrie électrique etc..., mais exclut les produits de commodités comme les matériaux de construction et les réfractaires.

- Il identifie et liste en temps que céramiques techniques avancées 500 types de produits différents.

- Il établit un vaste système de classification pour les céramiques techniques avancées qui est susceptible de recevoir des extensions et d'inclure de nouveaux produits voire même de nouveaux types de céramiques.

- Il apporte un système de classification non-hiérarchique de type matriciel qui est accessible par plusieurs entrées et permet donc de construire des bases de données relationnelles.

- Il propose un système de codage lisible par une machine, bâti autour de 4 champs de descripteurs indépendants, eux-mêmes sous-divisés, qui peuvent être séquencés dans un ordre quelconque selon la préférence de l'utilisateur. Chaque champ de descripteurs est identifié séparément par une unique lettre initiale de code.

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A pour les Applications.

C pour la nature Chimique et le type du produit.

P pour le Procédé de fabrication.

D pour les Donnés sur les propriétés.

Ces lettres de code servent à séparer les champs dans les longues chaînes de codage. Des listes détaillées sont fournies pour un codage complet par sous-catégories pour chacun des champs de descripteurs indépendants.

Les usages que l'on peut faire de ce système de classification sont multiples. Son utilisation au niveau d'une entreprise est intéressante pour rassembler des bases de données sur la conception et les propriétés des matériaux, pour la tabulation des inventaires, ou pour la facturation. L'industrie peut utiliser le système pour collecter et trier des données sur le comportement du marché, les dépenses R & D ou pour les classement de la documentation scientifique. Au niveau gouvernemental, les système pourra être utilisé pour collecter des données économiques à l'échelon national et international, ou d'autres statistiques stratégiques, ou encore pour déterminer l'évolution démographique du domaine.

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AUSFÜHRLICHE ZUSAMMENFASSUNG

Die modernen technologischen Erfordernisse führen zu einer Minderung im Gebrauch der Massenwerkstoffe bei einem gleichzeitigen Anstieg des Bedarfs an maßgeschneiderten Werkstoffen, die vollständig neue Funktionen oder alte Funktionen auf viel bessere Weise erfüllen. Dementsprechend erscheint regelmäßig eine Welle neuer Produkte im Handel, bei denen Hochleistungswerkstoffe eingesetzt werden. Unter diesen neuen Werkstofftypen hat sich die Technische Hochleistungskeramik als ein Werkstoff erster Güte herausgestellt, hat die Verbesserung der gegenwärtigen Technologien zugelassen und neue Technologien ermöglicht.

Die Technische Hochleistungskeramik ist seit Jahren eine Marktgröße, und das Leistungspotential ist noch nicht ausgeschöpft. So wird der Weltmarkt im Jahr 2000 auf mehrere 10 Milliarden Dollar geschätzt. Trotzdem wurde Technische Hochleistungskeramik nicht als eine getrennte Werkstoffklasse, die sich von anderem keramischen Material unterscheidet, allgemein anerkannt. Heutige Standardisierungssysteme sind veraltet. Sie müssen schlüssig der Tatsache entsprechend weiterentwickelt werden, daß Technische Hochleistungskeramik und andere neue Werkstoffprodukte zusammen mit den mehr traditionellen Werkstoffen übereinstimmend klassifiziert sind. Anderenfalls würde jede Facette in Wissenschaft und Technologie, die jeweiligen Bereiche der Wirtschaft, vom einzelnen Wissenschaftler und Verbraucher zu den Herstellern und ganzen Industrien, zur Finanzwelt, den Regierungen und Nationen ihr eigenes System zur Kennzeichnung und Klassifikation Keramischer Werkstoffe entwickeln, eigene Bezeichnungen einführen und Listenspezifikationen entwickeln, die eher häufig als gar nicht zueinander im Widerspruch stehen. Dieser auseinanderlaufende Prozeß ist bereits im Gange.

Die Standardisierungsfrage ist komplex, aber eine erste offensichtliche Notwendigkeit ist die Entwicklung eines Klassifikationssystems für Produkte aus Technischer Hochleistungskeramik, das Stück für Stück bestimmt, wofür sie sind, wozu sie dienen und, falls Statistiken oder andere Datensammlungen erstellt werden, das den Grad der damit verbundenen Bearbeitung mitteilt. In der Erkenntnis dieses Erfordernisses erstellte das Versailles Project on Advanced Materials and Standards (VAMAS) im Jahr 1988 ein neues Projekt, die Technische Arbeitsgruppe Nr. 14 (TWA 14) zur Klassifizierung von Technischer Hochleistungskeramik, um eine pränormative Grundlage zu schaffen und einen Rahmen zu erstellen für ein international annehmbares System. Drei strategische Ziele von TWA 14 kennzeichneten die Zielrichtung der internationalen Bemühungen:

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1. Bestimmung und Bewertung der Fragen im Zusammenhang mit der Entwicklung eines Klassifikationssystems für Technische Hochleistungskeramik

2. Erstellung einer Klassifikationsstruktur, die zum internationalen Gebrauch in einer vielfäligen Weise einschließlich industrieller, wirtschaftlicher, statistischer Indikatoren, Werkstoff- und Werkstoffeigenschaftsdatenbanken, Produkt-, Normen-und Literatur-Einordnung geeignet ist

3. Entwicklung von Mechanismen und internationalen institutionalisierten Verbindungen für die Einführung des Systems.

Die Ziele wurden durch einen Arbeitsplan erreicht, der die folgenden Elemente einschloß: Bewertung der existierenden Klassifikationssysteme und Terminologie; eine weltweite Übersicht der Klassifikationspraxis und Prioritäten der Industrie sowie einen internationalen Workshop zur Entwicklung einer detaillierten technischen Grundlage für das von der Industrie bevorzugte Schema. Diese und die daraus folgenden Arbeiten gipfelten in der Entwicklung eines umfassenden Klassifikationssystems für Technische Hochleistungskeramik, das durch die folgenden Elemente gekennzeichnet ist:

- Es bezeichnet "Technische Hochleistungskeramik" zum Zweck der Klassifikation als "eine hochentwickelte Hochleistungskeramik, die überwiegend nichtmetallisch anorganisch ist und spezifische funktionale Eigenschaften aufweist". Diese Definition schließt eine Vielzahl von Werkstoffen und Produktklassen ein, diedurch physikalische Anwendungen, wie mechanisch, thermisch, elektrisch usw., gegliedert sind, aber schließt Massenprodukte wie Baumaterial und Feuerfestmaterial aus.

- Es benennt und führt 500 verschiedene Produkttypen als Technische Hochleistungskeramik auf.

- Es erstellt ein zusammengefaßtes Klassifikationssystem für Technische Hochleistungskeramik, das erweiterbar ist, um neue Produkte oder andere Keramikklassen zu berücksichtigen bzw. einzuschließen.

- Es stellt ein nichthierarchisches Klassifikationsschema im Matrixformat dar, das über eine Vielzahl von Zugangs- und Abfragewegen zugänglich ist und eine relationale Datenbank bildet.

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- Es stellt ein maschinenlesbares Codiersystem zur Verfügung, das auf vier unabhängigen Beschreibungsfeldern und zugehörigen weiteren Unterteilungen basiert, das in beliebiger Reihenfolge angeordnet werden kann, so daß der Priorität des Anwenders entsprochen wird. Jedes Descriptorfeld ist einzeln durch einen einzigen Schlüsselbuchstaben gekennzeichnet:

  A für Anwendung
  C für chemischen Charakter und Produktform
  P für Verarbeitung und
  D für Eigenschaftsdaten.

Die einzelnen Codierungsbuchstaben trennen die einzelnen Felder in langen Codierfolgen. Es werden dataillierte Listen zur vollständigen Codierung durch Untergruppenbildung für jedes der unabhängigen Descriptorfelder aufgeführt.

Das Klassifikationssystem erweist sich als vielfältig verwendbar. In den Unternehmen kann es vorteilhaft zu Zwecken der Herstellung, der Konstruktion und für Werkstoffeigenschaftsdatenbanken, zur Erstellung von Listen zur Lagerhaltung oder Buchhaltung eingesetzt werden. Die Wirtschaft kann das System zur Sammlung und Gliederung von Trenddaten zum Marktverhalten oder für Forschungs- und Entwicklungs-Ausgaben oder zur Literaturordnung verwenden. Auf Regierungsebene kann das System zur Sammlung nationaler und internationaler Wirtschaftsdaten, für andere wesentliche Statistiken und für die Bestimmung des demographischen Umfeldes eingesetzt werden.

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SOMMARIO

A seguito delle variate necessita' delle tecnologie moderne, si assiste oggi a un declino dell' impiego dei materiali di largo consumo al quale corrisponde un aumento della domanda di materiali ingegneristici capaci di offrire funzioni totalmente nuove oppure di svolgere funzioni tradizionali ma in modo notevolmente migliore. Di conseguenza, vengono introdotti sul mercato con consistente flusso un insieme di nuovi prodotti basati sull'impiego di nuovi materiali. Tra questi tipi di nuovi materiali, le ceramiche avanzate si sono proposte come una classe tra le piu' interessanti in quanto hanno consentito il miglioramento di tecnologie tradizionali e reso possibili nuove tecnologie.

Le ceramiche avanzate sono attualmente, e lo sono gia' da vari anni, un interessante segmento di mercato. Confidando su aspettative di ulteriore consolidamento ed estensione degli impieghi, si stima che il mercato mondiale nel 2000 possa raggiungere decine di miliardi di dollari. Nonostante queste premesse, le ceramiche avanzate non sono state in generale considerate come una classe separata di materiali, distinta cioe' dagli atri tipi di materiali ceramici. Attualmente i sistemi di normazione sono arretrati e necessitano di correzioni onde renderli idonei a descrivere in modo coerente le ceramiche avanzate a gli altri prodotti a base di nuovi materiali, rispetto ai materiali piu' tradizionali. In caso contrario, ciascuna realta' operativa della scienza e della tecnologia e delle componenti economiche a queste associate, dai singoli ricercatori ai consumatori, ai produttori, all' industria utlizzatrice, alla comunita' finanziaria, ai governi e alle nazioni, vorranno darsi proprie definizioni di ceramica avanzata, proprie etichette, proprie specifiche che, piu' spesso che non, saranno in conflitto tra di loro. Questo processo di scarsa sintonia e' gia' in atto.

Il problema della normazione e' complesso, ma una prima ovvia necessita' e' di procedere allo sviluppo di un sistema di classificazione per i prodotti che usano ceramiche avanzate il quale definisca cosa esse siano e a quali fini esse siano idonee, e che una volta completato sia capace di fornire le informazioni di dettaglio per ciascun suo elemento. Sulla base della predetta esigenza, nel 1988 il VAMAS (Versailles Project on Advanced Materials and Standards) ha attivato un nuovo progetto TWA 14 (Technical Working Area, Number 14) indirizzato specificamente alla classificazione delle ceramiche avanzate al fine di offrire le basi di pre-normazione e una guida a blocchi per un sistema fruibile a livello internazionale.

L'attivita' del TWA 14 e' stata indirizzata su tre obbiettivi strategici:

1. Identificare e valutare le problematiche inerenti alla messa a punto di una classificazione per le ceramiche avanzate;

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2. Creare una struttura di classificazione appropriata all' uso internazionale e fruibile per una molteplicita' di funzioni quali indicatori statistici industriali/economici, banche dati per materiali/proprieta'/prodotti, categorizzazione di norme e dati bibliografici, ecc.

3. Sviluppare un meccanismo di collegamenti istituzionali internazionali per implementare il sistema.

I suddetti obblettivi sono stati conseguiti attraverso un piano di lavoro che comprendeva; una valutazione dei sistemi di classificazione e della terminologia esistenti; una rassegna a livello mondiale delle modalita' seguite dall' industria nella classificazione e relativi orientamenti preferenziali; un "workshop" internazionale inteso a individuare e realizzare una dettagliata base tecnica per lo schema di classificazione preferito dall' industria. Le suddette attivita', e quelle loro associate, sono culminate nello sviluppo di un sistema di classificazione onnicomprensivo per le ceramiche tecniche avanzate, che presenta le seguenti caratteristiche:

- Definisce, a scopo di classificazione, le "ceramiche tecniche avanzate" come un "materiale ceramico altamente ingegnerizzato, di alte prestazioni, inorganico ed essenzialmente non metallico, avente specifici attributi funzionali";

- Identifica ed elenca, come ceramiche tecniche avanzate, 500 differenti tipi di prodotto;

- Stabilisce un sistema completo di classificazione per le ceramiche tecniche avanzate suscettibile di essere esteso per accogliere nuovi prodotti o altre classi di ceramici;

- Fornisce uno schema di classificazione a base matriciale, non gerarchico fruibile mediante varie chiavi di accesso e procedure iterative per costruire banche dati;

- Fornisce un sistema codificato e informatizzato costruito con quattro campi descrittori indipendenti, e corrispondenti suddivisioni, che possono essere sequenzate in qualsiasi ordine al fine di soddisfare le preferenze dell' utilizzatore. Ciascun campo descrittore viene identificato da una lettera:

  A per l'impiego (Application)
  C per la chimica e la forma del prodotto (Chemistry)
  P per la tecnologia di fabbricazione (Processing)
  D per le proprieta' (Data)

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Le singole lettere del codice hanno anche la funzione di separare i campi, nel caso di codici molto lunghi. Vengono forniti dettagliati elenchi per una codificazione completa delle categorie in cui viene suddiviso ciascun campo descrittore.

Nell'insieme, il sistema di classificazione elaborato si presenta di grande utilita' sotto vari aspetti. Il suo impiego e' vantaggioso a livello di azienda per scopi che coinvolgano la progettazione, banche dati sui materiali, tabulazione di inventari, fatturazione. L'industria puo' utilizzare il sistema per ottenere e selezionare dati di tendenza del mercato o sugli investimenti di R&S, o per la categorizzazione di informazioni bibliografiche. A livello governativo il sistema puo' essere impiegato per acquisire dati economici nazionali e internazionali, e altre statistiche di grande interesse, o per studi demografici del settore.

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委員会総括

新しい時代の技術上の要請は材料技術における日用品の使用形態が減少し、同時にこれにともなって全く新しい機能や、仮に古い機能でもよりよいものを実現するエンジニアリング材料の要求が高まってきた。先進材料を使用した新製品の波が市場に定期的に登場するに至った。このような新材料の範疇のなかでも、ファインセラミックスは現在の技術を進展させ、かつ新技術を可能とすることができる重要なものとして浮上している。

ファインセラミックスは現在市場に存在し、これまでも多年それが続いていた。さらに先の展望としては、２０００年には世界市場は１００億ドルに達すると推定されている。にもかかわらず、ファインセラミックスは一般には独立した材料として明らかに他のセラミックスと異なる分類はされていない。現在のセラミックスの規格システムは明らかに古く、従来セラミックスと共にファインセラミックスやその他の新材料製品とも整合性をとりつつ再構築すべきである。それなくしては、科学技術とそれに付随する経済的側面あるいは各々の研究者、消費者から、また製造業者へ、全産業へ、財界へ、政府や国家への各側面でファインセラミックスの定義がそれぞれ異なってくる。製品に付随する種々の名称、製品表が欠落していたり、それぞれが混乱している結果を招いてしまう。

規格化の問題は複雑であるが、明らかにまず必要なことはファインセラミックス製品の分類システムを構築することである。ひとつひとつの要素ごとに、それ何か定義され、有用であり、いつ統計やその他の資料が記録され、付随する現状のレベルがわかるものが構築されるべきである。この要請が認められ、ベルサイユサミット先端材料と規格に関するプロジェクトが１９８８年に第１４委員会（ＴＷＡ１４）を発足させ、同委員会はファインセラミックスの分類とそれを先行的規格化に資し、国際的に受け入れられる構築された指標を作る作業を担当することとなった。ＴＷＡ１４では以下の目的を国際的に達成することとした、すなわち、

（１）ファインセラミックスの分類システムを開発するときの固有の問題を見きわめ評価すること。

（２）国際的に明細表の形で使用できる分類システムを設定すること。これには産業的、経済的な統計資料、材料と特性のデータベース、製品、規格、参考資料の階層化を含むこと。

（３）システム使用のための国際的な機関の結合とそのメカニズムを発展させること。

これらの目的はつぎのような作業計画により達成される、すなわち現存する分類システムと項目づけの検討、世界的な分類の現状および産業での有用性のサーベイ、および産業的視野での有効性に対する詳細な技術的基盤を把握するためのワークショップの開催などである。これらと、さらにこれにともなうファインセラミックス

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の分類システム全般の開発を完結させる作業活動も含まれている。これらは、「ファインセラミックスを分類の目的で”高度の技術的、高度の性能のある、非金属無機物を主体とするセラミックスで特別な機能的特性を有するもの”と定義する。この定義は応用目的上機械的、熱的、電気的などの応用目的にそって、広い領域の材料や製品を包含しているが、建築材料や耐火物などは除外する。」

「約５００の異なる製品型態をもつファインセラミックスとりあげ、対応づけた。」

「新製品または他の種類のセラミックスを含有するものにも拡張適用が可能なファインセラミックスの包含的な分類システムの構築。」

「優先性のないマトッリクス型の分類概念でそれが多数の入力、関連するデータベースの構築に適合できるもの。」

「独立した４系列の大要素（フィールド）記述で構成された、コンピュータが解読できるコードシステムを提供し、ユーザーの要求にマッチしたどのような順位付けも可能な中要素も付加する。各々の独立な大要素は唯一の先付けコードで分割同定できること。大要素は

A．応用分類
C．化学組成などの特性と製品の形態
P．製造プロセス
D．製品特性

とする。これらの大要素記号は長い数字列の間をしきる役割も果たす。各大要素の中の詳細な中要素以下の数字列記号化も提供する。」

全体の分類システムの有用性は多岐にわたる。これの利用は、企業ベースでは設計群、物性データベース、特許情報の表式化、発注仕様の作製などに有用である。企業はこのシステムを市場動向データの集積や仕分け、研究開発課題の発掘、参考資料の階層分けなどにも使用できる。政府レベルではこのシステムを国内および国際的経済データ、統計の現状の集積、この分野の統計の位置づけに使用できる。

「付記」本委員会に呼応してセラミックス系新素材の国際標準化に関する国内委員会を（財）日本ファインセラミックス協会において設置し技術的な検討を行ってきたが、分類システムとして完成したものではなく、さらに検討が必要である。しかし、ＥＣなどではこれを本格的な規格にする作業が進行しており、今後それらをＩＳＯにおいてさらに全世界共通の分類規格にする努力をはらう必要がある。わが国の広範囲なファインセラミックス製品の製造あるいは研究開発は他を断然越えているので、国際的にもわが国が寄与するところははなはだ大きいと言うべきである。

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Introduction

An international survey and workshop on the classification of advanced ceramics [3] found that most respondents defined advanced technical ceramics as

> "highly engineered, high performance, predominantly non-metallic, inorganic, ceramic materials having specific functional attributes".

This definition describes a diverse range of materials and product classes usually distinguished by their primary physical application, e.g. mechanical, thermal, electrical, etc.

The principle behind the system proposed in this ISO/TTA was established in meetings of the Versailles Project on Advanced Materials and Standards (VAMAS), Technical Working Area (TWA) 14, and the task of the consultants was to establish the terminology and a means of coding it [3]. [See annex F for a list of the VAMAS working group members of Technical Working Area (TWA) 14, *Classification of Advanced Ceramics*.]

The primary objective of this ISO/TTA is thus to propose a classification system for advanced technical ceramics which can form the basis for a multi-level database (to be defined elsewhere). A further objective is to define categories within the classification in order to define fully an advanced technical ceramic component or product which is encompassed by the following descriptor fields:

Application
Chemistry
Form
Processing
Properties

These descriptor fields were identified by the international survey [3] as being the most important fields in the identification and categorization of advanced technical ceramics. The fields Application and Chemistry were found to be of primary importance, whereas the others were recognized as being important if a more rigorous identification or description was required.

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Advanced technical ceramics — Unified classification system

1 Scope

This ISO/TTA proposes a unified classification system for advanced technical ceramics, intended to meet the following objectives.

— It should provide a comprehensive description of materials, products and applications of advanced technical ceramics.

— It should be able to accommodate new materials and products as they become available.

— It should be accessible via the following four descriptor fields, either individually or in combination:

Application
Chemical character (including form)
Processing
Property data

— Its coding system should be machine readable, thereby providing a means of sorting data within the descriptor fields.

— Its coding system should be such that it can be simplified by truncation and elimination of redundant characters or, where only limited information is required, by limitation of the number of descriptor fields.

— The coding system should be simple to use and employ characters and strings which are both easy to recognize and relate to classification information.

The term "advanced technical ceramics" covers a wide range of materials (some having complex chemistry) which may be used in diverse applications. For the purposes of this ISO/TTA it is assumed that advanced technical ceramics include materials in the following forms:

monolithic ceramics
powders
composite ceramics
fibres
glasses
glass ceramics
coatings
porous materials

and, in addition to the readily recognized "ceramic" materials, halides and single crystals.

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Specifically excluded from the classification system are the following:

elemental carbon, except for specific ceramic forms such as diamond, vitreous carbon and chemical vapour deposited (CVD) graphite;

elemental silicon, other than when it forms an integral component of or precursor for an advanced technical ceramic;

elemental germanium and other elemental or compound semi-metallic substances;

traditional ceramics based on clay, including

whitewares (e.g. tableware and fine porcelain),
sanitary wares,
floor and wall tiles, and
building ceramics (e.g. bricks and pipes);

unshaped and shaped refractories and bulk glasses for tonnage applications.

The mode of use of the classification system will be determined by the objective behind its use. It is not the purpose of this ISO/TTA to define how the system should be used, but examples are given of how it might be used. It is intended that the user can define the coding combination and the level of detail to suit his particular purpose.

2 Rationale for the coding system

It is clear that for a multicomponent classification system such as that proposed, the associated coding system is vital in ensuring that the system is workable. The coding system should also be comprehensive enough to encompass and describe adequately the wide range of data covered by the classification.

Since a fundamental objective is to provide a means of classifying any combination of descriptor fields in any sequence appropriate to user needs, each field is identified by a unique upper case letter code:

Application	**A**
Chemical character (including form)	**C**
Processing	**P**
property **D**ata	**D**

These letters do not appear in any other part of the coding system and hence can be used uniquely to identify a given descriptor field and hence the sequence in which the fields are used need not be fixed. The letters also act as field separators in long coding strings — the presence of one of the letters indicating that what follows (i.e. until the next descriptor field letter occurs) relates to that descriptor field.

In addition, it is envisaged that for most users only a limited number of descriptor fields will be relevant. An example of the use of the classification system by limited descriptor use may be the user seeking statistical information on product manufacture or sales where only application and/or chemical character will be of interest. A more detailed outline of the likely use of this form of classification system is given in table 1.

One of the findings of the questionnaire on this topic [3] was the relative importance (or perceived usefulness) of the application and chemical character descriptors, and it is clear that the use of the classification system by these two descriptors should be as convenient as possible.

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3 Abbreviations

CVD	chemical vapour deposition
HIP	hot isostatically pressed
PSZ	partially stabilized zirconia
PVD	physical vapour deposition
TZP	tetragonal zirconia polycrystals

4 Descriptor fields

4.1 Application

This field is identified by the upper case letter A.

Information in this field is contained in a three-digit code corresponding to a particular application. A full list of applications and corresponding numbers is given in annex A.

The coding format for this descriptor is

A*nnn*

where *nnn* is the number corresponding to the particular application.

In the list in annex A, applications are separated into, initially, a hierarchical series of areas by the principal functions of the product as defined by

— electrical insulation;

— electronic/ionic conduction;

— mechanical functions, including wear, at or near ambient temperature;

— thermal and thermomechanical functions, where dimensional stability at raised temperature, heat insulation, heat conduction or resistance to thermal shock are the principal functions, and where additionally mechanical loads may be applied;

— nuclear functions, where the component plays either an active or a passive nuclear role;

— optical functions, where the component plays a functional role as an optical element in reflection, refraction, transmission or absorption of electromagnetic radiation;

— chemical functions, including biomedical, where the component is employed for handling melts, chemicals, solutions or atmospheres because of its resistance to attack by them, and in the case of biomedical materials, a degree of biocompatibility;

— magnetic functions, where the component possesses properties allowing a functional magnetic role.

The first digit of the three-digit code is given by the principal physical function as above. The subsequent digits are non-hierarchical, and follow the listing in annex A. To aid the identification of codes, an alphabetical index of applications is given in A.3.

4.2 Chemical character (including form)

4.2.1 General

This field contains information relating to chemical character and form, and is identified by the upper case letter C.

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