Transactions of the Materials Research Society of Japan 29 [3] 731-733 (2004)

A Fresh Dimension to Interface Research -Geometrical Interface Engineering and Research management-

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Through collection and analysis of information on materials research trends, now I have interests in "material design" and also "interface research". For the establishment of the material design technique and the new collaborative and comprehensive research on interface, I propose a new concept "Geometrical Interface Engineering (GIE)" as a result of discussions with several researchers. GIE is defined as the technology which controls geometric turbulence in the interface in time/spatially and it improves characteristics and functions of materials (system). This paper also refers to a proposal for a new research style considered to be suitable for the promotion of GIE.
Key words: interface, geometry, material design, geometrical interface engineering

1. INTRODUCTION

Although I recognize how fragile conclusions drawn from interviews, questionnaires, and discussions tend to be, most materials researchers would readily agree that there are some big trends in materials research. In this paper, the importance of the comprehensive interface research which aimed at the material design is pointed out by paying attention to 4 trends mentioned later.

Moreover, a new concept "Geometrical Interface Engineering (GIE)" is proposed for promoting collaborative research on interface by researchers who have different backgrounds, and a new research style for GIE is also considered.

2. FOUR BIG TRENDS IN MATERIALS RESEARCH

Here I introduce 4 big trends in materials research as conclusions drawn from interviews, questionnaires, and discussions with experts.

Firstly, Figure 1 expresses signs that the mainstream of materials research is shifting from element study (single-phase/single-material study) to materials system study (multi-phase/multi-material study) in order to meet the demand of requested characteristics and functions. [1] Figure 2 shows that the research which creates materials (system) equipped with advanced characteristics and functions (such as composite characteristics, the recognition/selection abilities of specific materials (sensor functions), stimulus responses, self-restoration abilities, etc.) with combination of various materials is progressing.

Secondly, Figure 3 shows that expeditious development of new materials/devices are required in society (3E problems: Environmental, Economic, and Energy problems). [2]

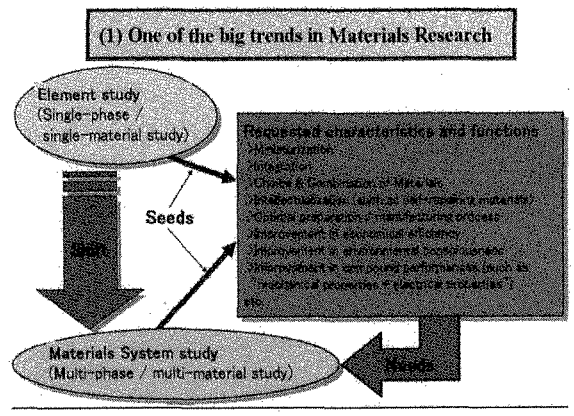

Fig.1 Trend (1): From element study to materials system study

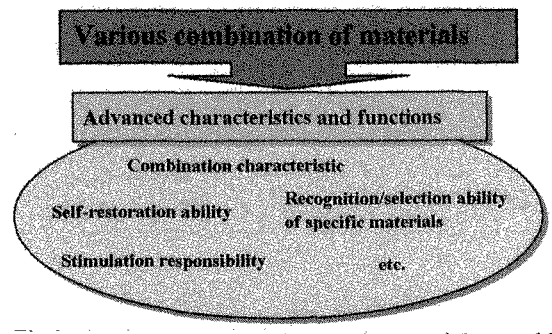

Fig.2 Various combinations of materials enable materials (system) to realize advanced characteristics and functions

Thirdly, Figure 4 shows that the concern about soft materials, such as polymer gels, conductive polymers, piezo polymers, and liquid crystal elastomers, have been

relatively increasing compared to hard materials, such as metals and ceramics. (The demand to systems which have direct contact with people, such as the aged care robots, small lightweight actuators, flexible displays, etc., is increasing.) [3]

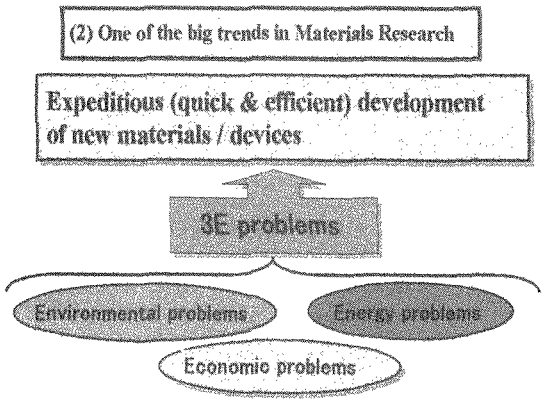

Fig.3 Trend (2): Expeditious development of new materials/devices

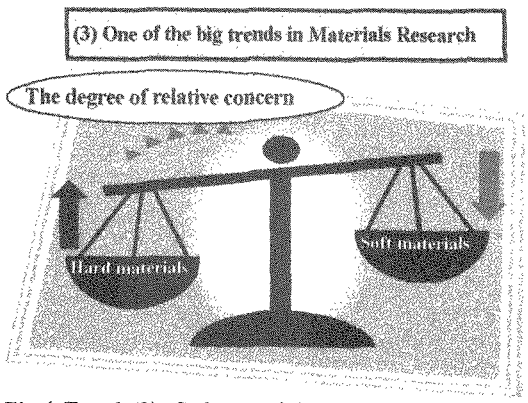

Fig.4 Trend (3): Soft materials with increasing relative concern

Fourthly, Figure 5 shows that the extension of the application range of micro-structure preparation and processing techniques by use of nanotechnology. (Now we can get not only flat thin films but also three-dimensional structures, curved/flexible thin films, straight lines, spirals, and quantum dots.)

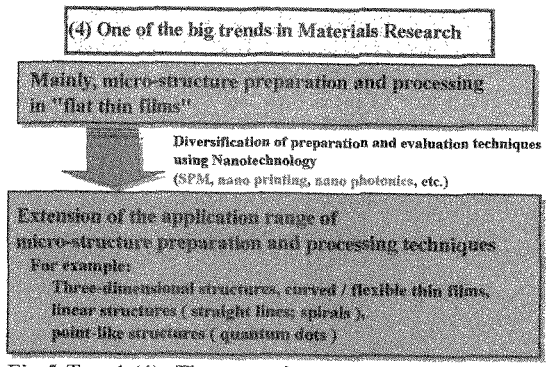

Fig.5 Trend (4): The extension of the application range of micro-structure preparation and processing techniques

3. THE NECESSITY FOR THE INTERFACE RESEARCH WHICH AIMS AT THE MATERIAL DESIGN

I think that we need to get out of "the material development based on trial and error" for filling demands of trend (1) and (2) in the long run. It seems natural to examine an establishment of "quantitative rational material design technique" as one of the promising researches that fills the demand of trend (1) and (2).

Then, what will be needed to establish the material design technique?

(a) Collaborative research on the interface by researchers with different backgrounds.
At present, the extrapolation of semiconductor theory is applied to the analysis on properties in the inorganic/organic interface. Cf. trend (1)
(b) Research on each interface composition element.
Compared with the silicon technology which supports the modern electronics society, it can be said that understanding about soft materials themselves is in a developing stage. Cf. trend (3)
(c) Research on controlling technique of geometric turbulence in the interface in time / spatially.
SPM, nano-printing, nano-photonics, etc. Cf. trend (4)

Considering these points ((a)-(c)), I think that the comprehensive interface research is necessary for establishing the material design technique.

4. A PROPOSAL OF GEOMETRICAL INTERFACE ENGINEERING

Then, how should "comprehensive interface research" be promoted? What should we carry out for involving in researchers who have different backgrounds and promoting the comprehensive interface research?

I propose Geometrical Interface Engineering (GIE) to reply to these questions. GIE is defined as the technology which controls geometric turbulence in the interface in time / spatially. GIE improves characteristics and functions of materials (system).

For example, it assumes that GIE deals with the relationship between interface energy and interface structure; dimension of interface and characteristics/functions; grain boundary junction angle and characteristics/functions; molecular orientation and characteristics/functions; roughness of junction planes and characteristics/functions; curvature and characteristics/functions; interface decoration patterns and characteristics/functions; dispersion state in fluidity material and characteristics/functions and etc.

For the establishment of the material design technique, researchers in dissimilar fields gather under the common concept (geometry) and the new collaborative research

on the interface will be constructed. (Fig.6)

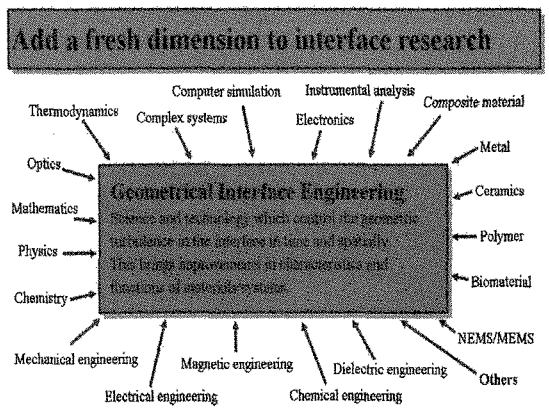

Fig.6 Geometrical Interface Engineering

5. RESEARCH MANAGEMENT STYLE FOR GIE

It is necessary for GIE to transversely and simultaneously examine splitting fields. Therefore, we need to change the conventional research managing style to the research managing style united with the feature of GIE.

The conventional research has been a "knowledge intensiveness and integration research". In this style of research, limited numbers of researchers monopolize the information (raw data of experiments, know-how, etc.) which is not known only by reading the paper currently published.

Unlike the above, "knowledge joint ownership and collaboration research" is proposed as a new research style in consideration of the feature of GIE. In this style of research, new knowledge is created and is accumulated with the collaboration among many and unspecified researchers who widely open and share the information on all the stages acquired through repetition of mutual study spontaneously and affect each other. [4], [5]

When the research managing method suitable for GIE is adopted, the problem on research promotion still remains. A really creative part in research activities is not produced by a team, but by a certain individual brain. Therefore, the clarification of role/responsibility of leadership/management in research activities is important. (Who takes "leadership" in what kind of case, or how should we "manage"/ make use of new knowledge for other research activities?) We may have to establish a new methodology through trial and error.

6. DISCUSSIONS

However GIE is proposed as a means to promote the comprehensive interface research, there are many points which must be solved.

(Ex.1) Each research on individual interface is recognized important. Then, what kind of meanings/advantages are there in the comprehensive interface research?

(Ex.2) Is the viewpoint of GIE really effective for the promotion of the establishment of the material design technique?

(Ex.3) Are there any problems in coordinating the comprehensive interface research based on "geometry"?

After reminding of big trends in materials research, fresh values and meanings are given to the traditional interface research by this paper. I will be glad if the proposal of GIE become any help to the people concerned.

7. ACKNOWLEDGEMENTS

I wish to express my gratitude to Prof. Mitsumasa Iwamoto (Department of Physical Electronics, the Tokyo Institute of Technology), Prof. Toyonobu Yoshida (Department of Materials Engineering, School of Engineering, the University of Tokyo), Prof. Yuichi Ikuhara (Institute of Engineering Innovation, School of Engineering, the University of Tokyo), and Dr. Kohei Soga (Department of Advanced Materials Science, Graduate School of Frontier Science, the University of Tokyo) for providing information and for stimulating and helpful discussions.

8. REFERENCES

[1] T. Sakuma and M. Murakami, *Materia Japan* vol.42 (9), 611-613 (2003) (in Japanese)
[2] "The Seventh Technology Foresight (NISTEP REPORT No.71, July 2001)", National Institute of Science and Technology Policy (http://www.nistep.go.jp/index-e.html)
[3] M. F. Ashby, "Materials selection in mechanical design", Butterworth-Heineman, Oxford (1999)
[4] J. Takano, *IUMRS Facets* vol.2, No.3, 17-18 (July 2003)
[5] J. Takano and N. Koguchi, *Transactions of the Materials Research Society of Japan* 28 [3] 537-540 (2003)

(Received October 8, 2003; Accepted October 20, 2003)