these new processes have their own merits and devrerito compared with conventional other processings. Some countermeasures must be necessary to improve their potential.

My question is what should we do in order to improve these new technologies for applying to pratical use in production. Please point out one or two important points which we should consider and solve for improvement of each process Dr. Wehr has classified.

Answer (*Dr. M. Wehr*) :

As far as I know, some of the processes I have described are already in development, and will be on production line (in less than 2 years) in a near future, but nor is the field of ceramics coating (it means that there is no more problems for certain of these processes, in some companies). It is the use of the stellite coating of turbine blades by powder injection processes assisted by laser, process which is already in development. It is also the case of deposition of metal by laser CVD for mask depositing, and this process is already sold on the market.

"Formation of High Function Ceramic Surface by Ion Implantation"

Prof. N. Iwamoto

Question (*Dr. Iwaki*) :

I am much interested in your work, and I think you suggest the possibility that a certain ceramics transforms other types of ceramics by high fluence ion implantation.

I think that there are two big categolies in the fields of surface modification of ceamics by ion implantation; one is the metallization of the near surface layers of ceramics by metal ion implantation and the other is the transition of types of ceramics by high fluence ion implantation with light ions such as carbon, nitrogen and oxygen.

Your report is an example of the latter case, you introduces preliminary experimental results with micro-characteristics of nitrogen implanted SiC measured by means of RBS, XPS, SIMS and laser Raman. It seems that the results indicate the formation of nitrides, oxides, oxinitrides, carbonitrides, graphite and so on. We have investigated the surface layer modification of non-oxide ceramics such as AlN and SiC by metal ion implantation with a high fluence. We also found such similar results as the formation of graphite and oxides in SiC due to ion implantation.

In order to clarify the formation of compounds in nitrogen implanted SiC, I will ask you three questions.

1. It seems that the RBS spectra for nitrogen implanted SiC, that is the as-implanted SiC, indicate the enrichment of carbon near the surface layers. Is it true?
2. You explain that the XPS spectra for Si_{2p} indicate the occurrence of oxidation. Please show us the ratio of compositions for all of the elements in nitrogen implanted SiC and the XPS spectra for O_{1s}.

Lastly, are your experimental results desirable from the standpoint of improvement of physical, chemical and mechanical properties?

Answer (*Prof. N. Iwamoto*) :

1. As shown in Fig. (7), we can conclude that the decomposition of SiC, that is to say, to form free carbon and silicon occurs with nitrogen ion implantation at the surface of specimen. Also it is recognized that the higher the ion implantation is, the greater free carbon forms.
2. As shown in Figs 4(a), (b) and 5(a) and (b), it can be seen the formation of SiO_2 with after-heat-treatment of 1273°C x 1hr. (Si_{2p} value=103.5eV)
   In Fig. 4(a) and (b), the only formation of SiO_2 with the disappearance of Si_3N_4 can be determined. Of cource, in Fig. 4(a) and (b), the relation between the ratio of Si_3N_4/SiO_2 and the change of after-heat-treatment temperature is given so that the former can be calculated by using convolution method.
3. Though the author did not present in this publication the improved behaviors of the mechanical properties such as wear-resistance, hardness and fracture toughness with ion implantation in SiC, this technique is superior one for the improvement of physical, chemical and mechanical properties of every matter.

Concluding Remarks

Prof. H.D. Steffens and Prof. N. Iwamoto

In session II, the progress on the surface modification procedures have been treated.

At first, Professor Steffens of Dortmond University in West Germany presented the paper titled "Arc and Plasma Spraying Today and in the "90th". He emphasized that arc and thermal spraying technologies were becoming more and more important technique to give special properties such as high resistance to corrosion and wear to materials. The production of composite texture composed from austenitic steel fiber embedded into MCrAlY alloy phase with after-hot isostatic pressing was introduced. Following, he said that the application of vacuum plasma spraying for MCrAlY coating on turbine blade was important. However recent endeavours to apply this procedure to coat reactive materials such as titanium and tantalum have been paid. He presented new plasma spraying concepts to use new gun which can obtain high-velocity and therefore to able to obtain good adhesion and homogeneous coating texture. The example is water-stabilized plasma generators consisting of rotating water-cooled anode and a slowly-consumed graphite cathode which can use high powers up to 200kW and feeding avility such as 50kg/h Al_2O_3. To hold longer residence time of sprayed particles in the plasma and to reduce electrode erosion by introducing higher energy, magnetic-field stabilized pulsed means and high frequency plasma torch have been developed. On the other hand, arc spraying method has been used longer time for the simplicity to be able to use metallic wire. At that time lamellar finer-crystalline structured coatings are formed.

The authors developed arc-spraying which can use cored wire so that pure, precipitated hard phases can be included in the cores. As an example, precipitation of chromium carbides in mild steel has been possible to prevent the oxidation of alloying elements during the process.

Furthermore high-quality coatings of manganese-alloyed steel, chronium-nickel steel as well as titanium is now examining by using vacuum arc spraying. With this method, very dense, pure and corrosion-resistant coatings of reactive materials for the use in chemical apparatus construction is possible.

The following paper titled "Formation of Ceramic Coating by Laser Process" was presented by Dr. Wehr. The paper concerns the review of laser technology for improving the mechanical properties such as wear-resistance or hardness of metals and alloys The injection of lighter elements such as oxygen or nitrogen by using the liquid phase process such as water, liquid N_2, NH_3 or O_2 or organometallic solution, toluen etc. was done with laser irradiation. In the case of tantalium and titanium, the oxidation or nitridation occurred. Similarly, the application of laser gas alloying procedure by using various species such as (N_2, O_2 and gas mixtures) was alloyed into titanium. It was confirmed that O_2 was not effective to improve surface hardness change but N_2 addition to methane showed remarkable effect.

The author concluded that very thick (several mm), hard (2000kg/mm^2), wear resistant coatings of complicated shape as turbine blade can be obtained by powder deposition method with high speed. And the comparison between LCVD and LPVD methods based on coating velocity was done. In the production of electronic and optical applications, the former in spite of the complexity of the experimental conditions to be used for appropriate coatings is now doing. It has been summerized at which regions and what kinds of the coating methods are suitable especially for the electrical applications.

As third paper, professor Iwamoto presented a paper titled "Formation of High Function Ceramic Surface by Ion Implantation". The work concerns nitrogen ion implantation into SiC. SiC and Si_3N_4 have respective prominent mechanical and thermal properties. If the composite of them could be manufactured, it well be served for the use under severe environments. It is known the surface of materials governs the characteristics such as high temperature corrosion, chemical corrosion, and mechanical behaviors. For the reason the surface modification is recommended for every species of materials. Ion implantation technique is splendid because the implantation species and the dose can be selected independently. Several papers have been presented in combination with SiC and nitrogen ion. However only the problems as for amorphization effect and the mechanical property change were treated. In this presentation the author studied the chemical state of nitrogen as implanted and after heat-treated and the possibility of the decomposition of SiC with nitrogen implantation by using XPS and Raman spectroscopic means. Depending on the accelerating voltage and implantation dose, the chemical state changes of nitrogen and therefore oxidation behavior after heat-treatment showed remarkable difference. The decomposition of SiC besides nitrogen implantation was confirmed and the graphitization occurred with the after heat-treatment. It is the first paper that the behaviors of nitrogen, carbon and oxygen were investigated on the nitrogen implanted SiC in detail. The informative knowledge on SiC, Si_3N_4 and SiO_2 could be given.

Three papers, plasma spraying, laser technology and ion implantation techniques, were presented in this meeting. Respective methods have each characteristics in the field of electronic, mechanics and thermal uses. We could select the methods depending on our object in future.

(Prof. N. Iwamoto)