Journal of Korean Institute of surface Engineering
Vol. 32, No. 3, Jun., 1999

BORIDING OF STEEL WITH PECVD METHOD

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Abstract

Boriding is one of the chemical method to increase surface hardness as well as carburizing, and nitriding. Gas boriding and boron paste boriding methods were investigated to replace salt bath boriding. Boron paste boriding method is selected due to safety, small waste and low cost. And then boriding is also carried out micro-pulsed PECVD in order to increase efficiency of boriding. Mechanical properties, microstructure, surface concentration, and depth profile of borided layer is investigated by micro-vickers hardness tester, SEM, XRD, and AES.

Key words : *boriding, boron paste, PECVD*

1. INTRODUCTION

Boriding is one of the chemical methods to achieve the hardening of steel like nitriding or carburizing[1]. The surface layer of the borided steel shows higher hardness and exhibits better resistance to corrosion and fatigue than those of the nitrided or carburized steel[2]. However, currently need salt bath method for boriding produces toxic wastes and heat efficiency is low[3]. Thus, new boriding methods are requested. New methods are gas boriding and boron paste boriding[4]. Boriding is carried out micro-pulsed PECVD in order to increase efficiency of boriding. Gas boriding is not adequate because gas is toxic and very expensive. And then, boron paste boriding method is more feasible method. Mechanical properties of the surface are measured by micro-Vickers hardness tester, depth profile and surface elements were analyzed by AES and XRD, and microstructure is observed by SEM.

2. EXPERIMENTAL PROCEDURE

2. 1 Gas boriding

S45C carbon steel was used as substrate of boriding. The specimen were polished and cleaned with aceton to remove organics. And cleaned samples were placed inside of PECVD chamber. Argon was purged and chamber was evacuated twice to make inert atmosphere. Chamber was evacuated to 5×10^{-3}torr and then was heated upto 750-850℃. After desired temperature was obtained, MFC controlled argon, hydrogen and BCl_3 gas were introduced into chamber. After 6 to 8hrs boriding, the chamber was cooled and vented with argon. Samples were retrieved from chamber to be analyzed.

2. 2 Boron paste boriding

Boron powder were mixed and suspended in alcohol and chloroform. Boron solution was dropped on substrate in a glove box to prevent oxidation. Argon was purged and volatile liquid was vaporized. Dried boron pasted samples were placed in PECVD chamber. Following sequences are the same as those of gas boriding. Fig. 1 shows schematic of PECVD equipment. In order to analyze the surfce properties, SEM micro-Vickers Hardness tester, AES, and XRD were used.

2. RESULTS AND DISCUSSION

2. 1 Gas boriding

In gas boriding, total pressure, temperature, gas ratio, plasma power and boriding hours were operating parameters to influence on borided layer. From preliminary test, pressure and boriding hours were fixed as 5torr and 7hrs respectively. And then the effect of the rest of operating parameter were investigated. Fig. 2 shows the effect of temperature on surface hardness. Temperature did not influence on surface hardness, however, considering decomposition of BCl_3 gas and kinetics, 800℃ was chosen as optimum temperature. Fig. 3 shows the effect of plasma power on surface hardness. Surface hardness was increased with plasma power and had maximum value at 300W and then plasma power was fixed at 300W afterwards. Fig. 4 shows the effect of gas ratio, BCl_3 to H_2, on surface hardness. At low gas ratio, high concentration of BCl_3 gas attacked steel substrate, while at high gas ratio media of boron source was lacking. Therefore at intermediate ratio 1:

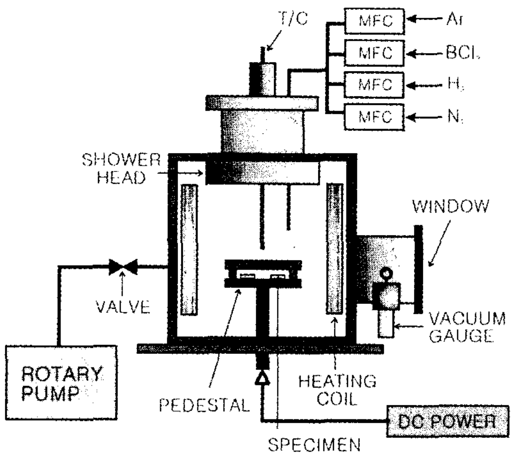

Fig. 1 Schematics of PECVD equipment.

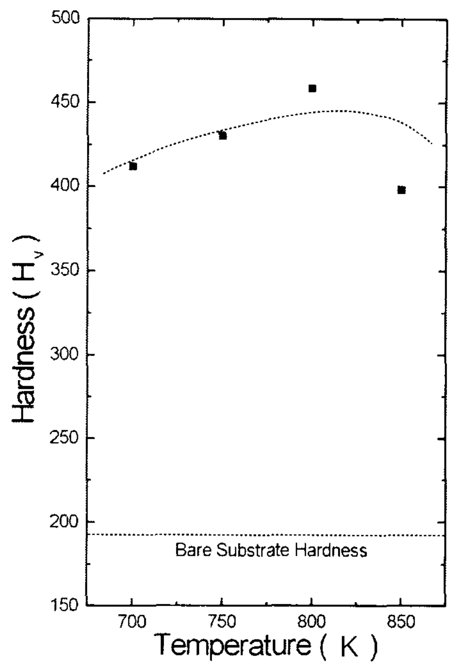

Fig. 2 Surface hardness versus temperature in gas boriding

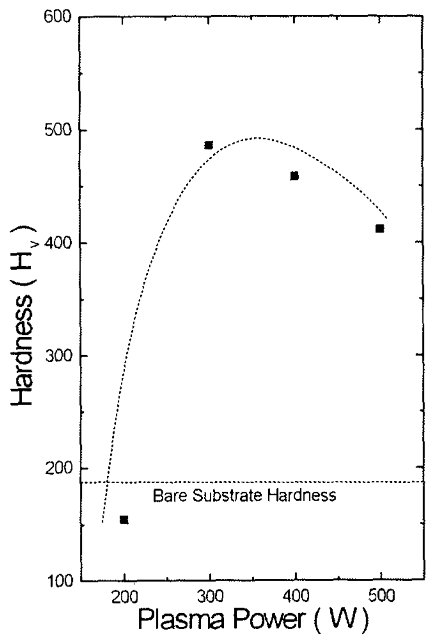

Fig. 3 Surface hardness versus plasma power in gas boriding

45 gave the highest surface hardness. From the above results, the optimum operating conditions were 800℃, 300W in plasma power, 1:45 gas ratio at 5torr in 7hrs boriding.

3. 2 Boron paste boriding

In boron paste boriding, plasma power is very important operating factor. At low plasma power boron paste had not completely reacted, while at high power many cracks were developed on surface of borided layer due to excess energy supply. Fig. 6 shows the effect of plasma power on surface hardness. Like gas boriding, at 300W hardness has maximum value. In boron paste boriding, the maximum hardness was obtained in conditions of 800℃, 300W, 80% Ar, and 20% H_2. The pressure and experimental duration were fixed in 5torr and 2 hours. The lower

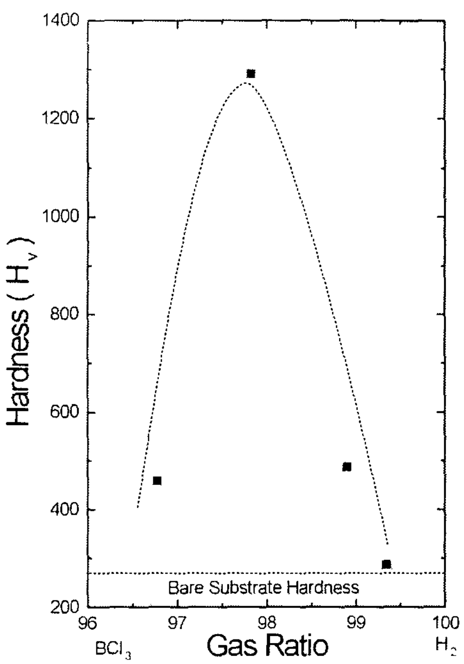

Fig. 4 Surface hardness versus gas ratio in gas boriding

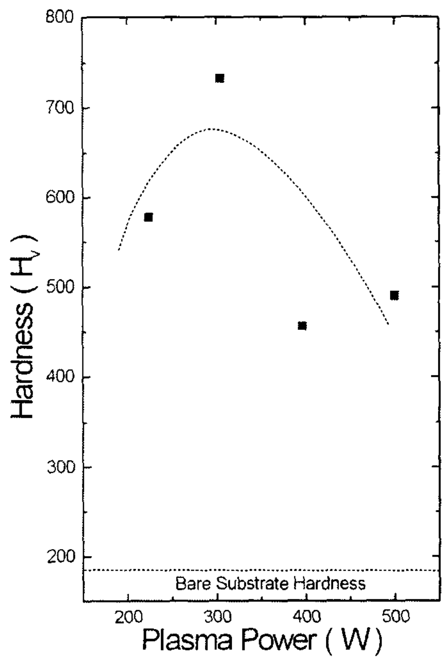

Fig. 5 Surface hardnes versus plasma power in born paste boriding

hardness was obtained under 800℃ due to the low activation and the hardnes was decreased over 800℃ due to tempering effect.

4. CONCLUSION

In gas boriding, the optimum operating conditions are 800℃, 300W in plasma power 1:45 gas ratio ($BCl_3 : H_2$) at 5torr in 7hrs boriding. In boron paste boriding, the optimum conditions are 800℃, 300W in plasma power. Gas ratio was also sensitive for the elements of energy transfer. Thus, the gas ratio needs to 80vol.% Ar and 20vol. %H_2. Due to high cost and toxicity of BCl_3 gas, boron paste boriding is more feasible method to replace salt bath boriding.

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