Tribological properties of Si-DLC coating against electrostatic discharge (ESD) effect

Young Sun Yun*, Jun Woog Park*, Chang Hee Shin*, Dong-Yeol Kim**, and Young-Jun Jang

*J Materials, Korea, **Korea Institute of Materials Science (KIMS), Korea

1. Introduction

The current state of the semiconductor industry is that as the size and line width of components decrease in the nanometer scale, the resistance to static electricity is decreasing, and during the advanced semiconductor manufacturing, packaging process, and chips are damaged by static electricity, which adversely affects product yields. Therefore, a solution that can improve the static electricity protection and durability of existing wafer carriers is required. Herein, alternative solutions such as (1) micro spray coating and (2) hydrogenated amorphous carbon (a-C:H) have been proposed to solve this problem. However, they cannot guarantee of tribological properties with discharge static electricity under an actual voltage application environment and have a short lifetime. In the case of the existing spray coating, the surface resistance is excellent at $<10^9$ ohm, but the mechanical hardness is very low at >1 GPa, so it cannot withstand durability in proportion to the applied load (1N = 580 MPa/Hertz contact pressure). In addition, in the case of a-C:H, it is difficult to achieve antistatic properties by increasing the sp^3 fraction, but it is difficult to implement more than 40%, which is the theoretical limit of chemical vapor deposition (CVD). However, the optical band gap control is possible by increasing the hydrogen content in the DLC coating, DLC with a high sp^3 fraction can be produced. However, when the hydrogen content exceeds the critical point at 40%, the mechanical properties decrease and the structure changes to a polymer-like structure, therefore DLC coating required an optimal hydrogen content control method during deposition. Therefore, this study is focus on the development of two kinds of functionally that simultaneously include electrostatic discharge resistance and durability for the introduce of expanding the applications of DLC coating to the semiconductor industry.

We propose a DLC coating including antistatic properties and a surface hardness of 20 GPa or higher by doping TMS (tetramethylsiane, $Si(CH_3)_4$) into acetylene (C_2H_2), the precursor materials of the a-C:H coating, to induce Si-C, Si-H bonds. In addition, the current antistatic coating is verified by using a two-point probe type surface contact resistance measurement (standard specification: IEC61340-2-3, 2016) [1], but this method can only measure static surface resistance and cannot verify durability. Therefore, we also present a reliability verification method using a durability tester for ESD coating under a dynamic electrical contact environment.

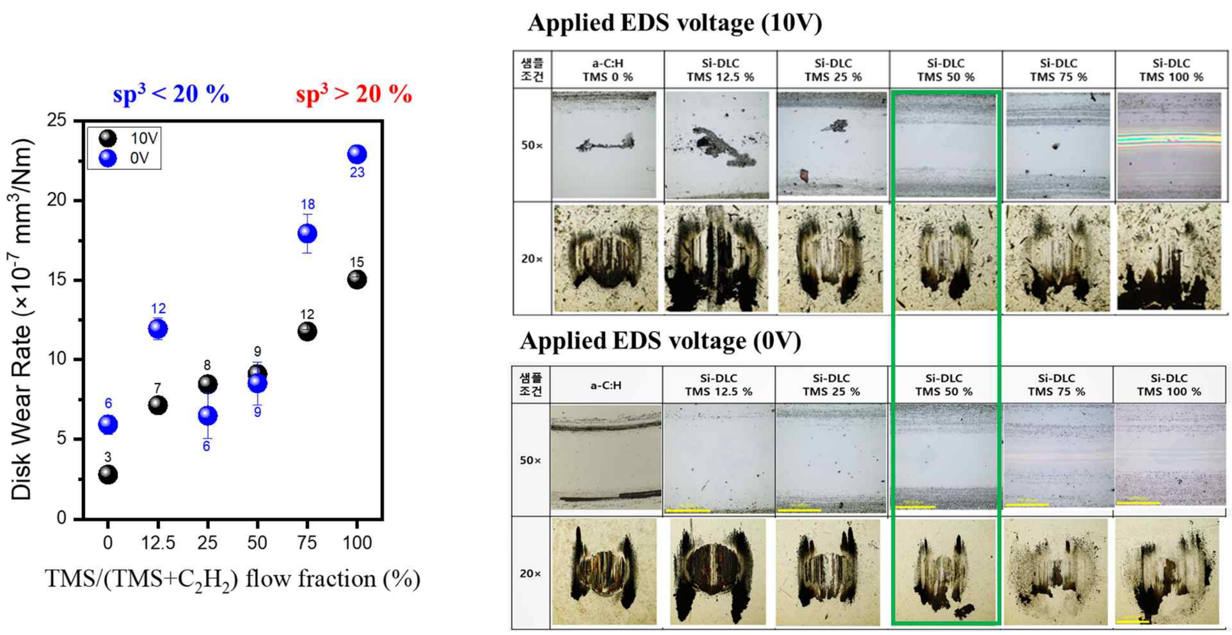

Fig. 1 Disk wear rate and optical images for the DLC coated disk and wear scar of the SUJ2 ball as a function of TMS doping ratio after the test a load of 1N.

Reference

1) IEC Webstore, https://webstore.iec.ch/publication/25218