7th Asia-Pacific Conference on Plasma Physics, 12-17 Nov, 2023 at Port Messe Nagoya

Suppression of substrate temperature by balanced magnetron plasma sputtering source

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The Magnetron sputtering deposition technique is used as a promised tool for semiconductor manufacturing such as seed layer depositions. Magnetron sputtering cathode uses an $E_z \times B_r$ drift motion that confines plasma particles above the target material to enhance plasma production and target utilization efficiencies. The commercially available magnetron cathodes have unbalanced magnetic field lines which diverge from the target surface to the substrate surface to give high ion irradiation to the target surface. Thus, in the balanced magnetron cathodes, the substrate temperature facing the sputtering target increases above 40 ℃ because the plasmas are transported through unbalanced magnetic field lines. Among them, we have developed a balanced magnetron cathode to enhance the plasma production efficiency compared with the conventional balanced magnetron cathodes. The developed magnetron cathode has a magnetic mirror configuration over the circular-shaped target material, namely, Magnetic Mirror-type magnetron cathode: M3C, as shown in Fig. 1.[1]

The M3C has good discharge performances for the low power density and low gas pressure operations (5 W of input power and 0.1 Pa of Ar gas pressure). This presentation shows the low-temperature sputtering performances of less than 40 ℃ by the M3C.[2] To estimate the plasma irradiation to the substrate surface, Langmuir probe measurements are conducted above the target as shown in Fig. 2. The attainable substrate temperature during the sputter deposition was verified by the temperature indicator label (Nichiyu Giken Kogyo Co. Ltd., Japan). Kapton tape was attached to prevent tungsten (W) film deposition on the temperature indicator labels.

We were able to suppress the temperature of the substrate temperature to the environmental temperature of less than 40℃ at a target–substrate distance of ≥50 mm with a DC input power of ≤30 W and an Ar gas pressure of ≤0.15 Pa. This was possible because the balanced magnetic field lines confined the plasmas near the sputtering target. By enabling film deposition on low heat-resistant substrates, this technique for suppressing the substrate temperature can be used in various application fields such as low-temperature sputtering deposition on a plastic mold of semiconductor devices, polyethylene terephthalates, and so on. We will also show examples of our metal coating results for biomaterial surfaces.[3]

References

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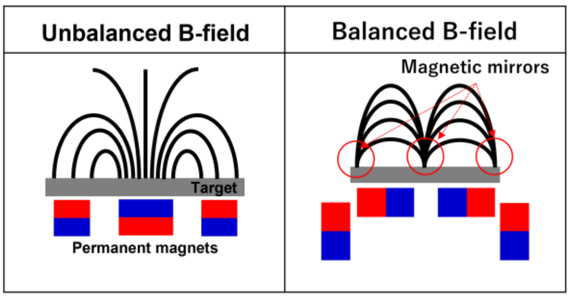

Figure 1. Schematic drawing for the comparison of magnetic field lines. Unbalanced B-field vs. balanced B-field by M3C are shown.

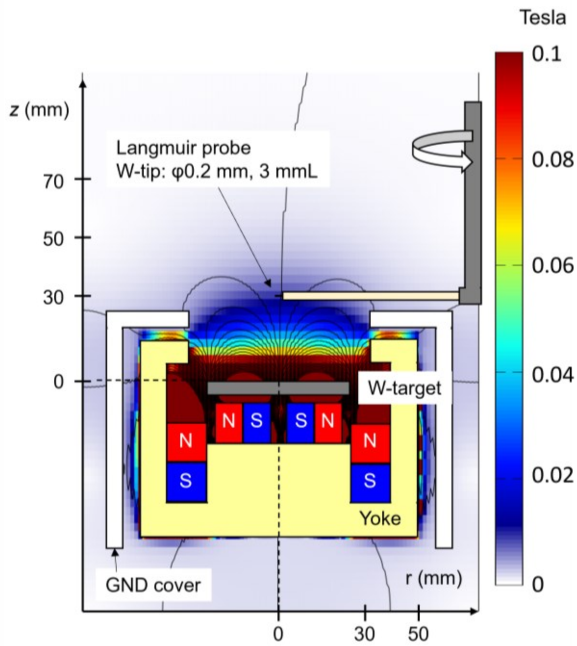

Figure 2. Schematic drawing of M3C and Langmuir probe setup. The radial and axial origins (r and z) are the center of the target surface.