EXTRACT COEFFICIENTS OF THERMAL EXPANSION OF TaN THIN FILM BY TUNING THE N_2 GAS FLOW IN THE PVD PROCESS

YAO-ZIH, LAI, yzlai@itri.org.tw
WEILEUN, FANG, fang@pme.nthu.edu.tw
YU-CHEN HSIN, currentdensity@itri.org.tw

Key Words: Coefficients of Thermal Expansion (CTE), Residual Stress, Tantalum Nitride (TaN), Micro Cantilever Beams, Gas Ratio,

Coefficients of thermal expansion (CTE) mismatch between different materials is an essential and critical concern in semiconductor development. During the manufacturing processes, the thermal budget will induce residual stress, occurring the deformation of the material. In the worst case, the thin film or the elements would be broken or failed. [1] However, these mechanical properties are difficult to determine and measure. In this study, we used the simple micro-cantilever beams array as the test key which was fabricated by the MEMS process. We deposited the TaN thin film on the different length cantilevers and then exploited the double layer method and Stoney equation to analyze its mechanical properties [2] [3]. Figure 1 shows the micrograph of the SiO_2 cantilever beam deposited with TaN thin film and whose geometry size is also measured by the SEM system.

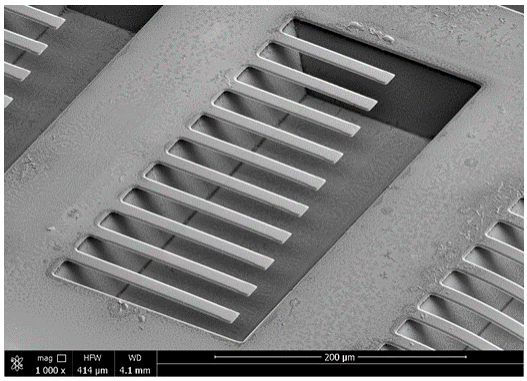

FIGURE 1 – CANTILEVERS DEPOSITED BY R_N=0.5

Many processes and approaches can form and deposit the TaN thin film, such as PVD, PECVD, and PEALD, etc. [4][5][6] For depositing the pure thin film layer on the cantilevers, we selected the PVD process with three gas ratio R_N=0.3,0.4 and 0.5, respectively. The gas ratio (R_N) can be expressed as $N_2/(Ar+N_2)$. We put the sample on the heater and heated it from room temperature to 30, 60, and 90 degrees. Figure 2 shows the profile and deflection of 140µm SiO_2 cantilevers deposit with R_N=0.4, and through the 3D profile measurement system to observe the variations with different temperatures.

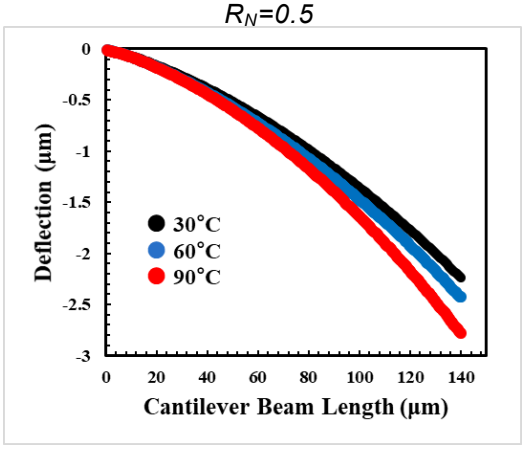

Figure 2 – Deflection heat from 30-90°C

Our study revealed that the cantilevers deposited with TaN thin film were deflected downward and affected by the temperature variation. Figure 3 shows the CTE results of TaN extracted by different conditions. It was effectively reduced from 3.02×10^{-6}/°C to 2.56×10^{-6}/°C as the N_2 flow raising.

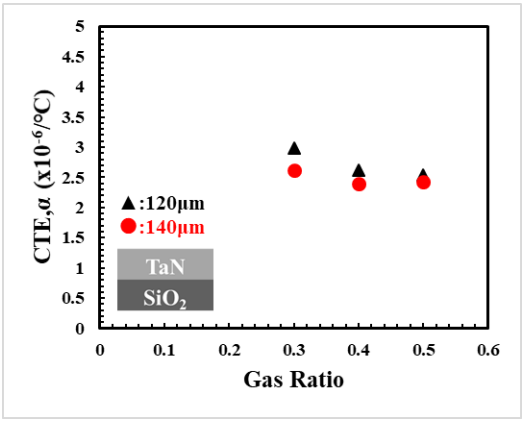

Figure 3 – CTE extraction results

References

[1] M. Grosser et al., *Thin Solid Films*, vol 629, pp 69-78, 2017
[2] W.Fang et al., *Sensors and Actuators A-physical*, vol. 77, pp.21-27, 1999.
[3] G.G.Stoney, *Proceedings of the Royal Society A*, vol.82, no. 553,pp. 172-175, 1909.
[4] S. Tsukimoto et al., *Thin Solid Films*, vol 460, pp 222-226, 2004
[5] K.Hieber, *Thin Solid Films*, vol 24, pp 157-164, 1974
[6] M. Grosser et al., *Thin Solid Films*, vol 629, pp 69-78, 2017