Dependence of Thermal Boundary Resistance on Depositing Gas Ratio and Temperature at the Interface of Ru/TiN/SiO_2 and Ru/Al_2O_3/SiO_2

Shuaizhe Ma[1], Tianzhuo Zhan[1], Zhicheng Jin[1]
, Motohiro Tomita[1], Yen-Ju Wu[2], Yibin Xu[2], Takashi Matsukawa[3], Takeo Matsuki[1,3] and Takanobu Watanabe[1]
[1]Waseda University, 3-4-1 Ookubo, Shinjuku-ku, Tokyo 169-8555, Japan
[2]National Institute for Materials Science, 1-2-1 Sengen, Tsukuba 305-0047, Japan
[3]National Institute of Advanced Industrial Science and Technology, 1-1-1 Umezono, Tsukuba, Ibaraki 305-8560, Japan

Introduction

With the development of semiconductor technology, the heat dissipation problem of the chip has been entangled with people, we set our sights on improving chip performance by improving the chip's heat dissipation capabilities [1]. Because thermal energy is conducted in different ways in metals and non-metals, there is thermal boundary resistance between the metal as the interconnects. Ru is being used as a new wire material and the low-k silicon dioxide as the insulator, which greatly affects the heat dissipation inside the chip. Our research is focused on finding ways to reduce the thermal boundary resistance(TBR).

Experimental

We prepared a sample of Ru / TiN / SiO_2 (thickness of each layer: 10nm) structure by magnetron sputtering, where SiO_2 is made as an insulating layer, TiN is the adhesive layer between the interconnects and the insulator. Finally, Ru is the metal layer as the interconnects. (Fig.1)

In the process of making TiN, we changed the ratio of Ar and Nitrogen. We also changed the temperature during the sputtering process. We changed the temperature to 300 degrees to investigate the effect of changing temperature on the TBR.

At the same time, we prepared Ru / Al_2O_3 / SiO_2 (thickness of each layer: 10nm) samples. For comparison, we also prepared Ru / Al_2O_3 / SiO_2 at 300 degrees Celsius. Then we tested their TBR using the Time-domain thermoreflectance (TDTR) method [2].

Results and Discussion

In this study, we hope to change the crystallization of TiN, silica and Ru by heating up during the preparation process. And to evaluate the effect of changing the crystallization on the thermal boundary resistance.

We obtained the following results. (Fig.2). For Ru / TiN / SiO_2 samples, as the specific gravity of the Ar gas decreases, the TBR gradually decreases. The higher temperature fabrication process reduces the thermal boundary resistance. In our previous research, XRD observations revealed that changing the ratio of nitrogen to argon during the preparation of TiN will change their crystallization. The TiN with different crystallization is different from the TBR of the other two layers. This is because better crystallization reduces the stacking faults and dislocations inside the crystal, so that less scattering is received during the phonon propagation, thereby transferring heat more efficiently. But for different materials, the change in crystal structure at elevated temperatures may be different. It is the reason why the higher temperature fabrication process reduces the TBR of Ru / Al_2O_3 / SiO_2 sample.

Conclusion

Through our research, we have found that changing the gas ratio and temperature during the preparation process changes the TBR of the sample. But for different interfaces, the changing trend and degree of TBR are not consistent

Acknowledgements

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References

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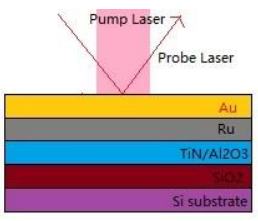

Fig.1 TDTR method

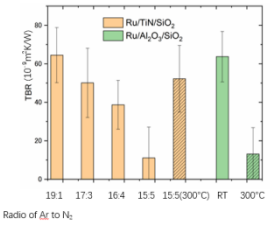

Fig.2 Result of TBR (TDTR)