Thermally Stable Ohmic Contacts on GeSn Layers

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Germanium tin doped (GeSn) alloy, unlike germanium, is a direct bandgap semiconductor, making it a good candidate for optoelectronic applications [1]. The most commonly used process for making an ohmic contact on germanium is nickel deposition and diffusion, which occurs during rapid thermal annealing to produce a stable Ni-Ge alloy with low sheet resistance and low specific contact resistance. However, if the tin addition does not change this phase sequence, Sn segregates at temperatures higher than 350 °C and affects the sheet resistance of the alloy [2]. Such phenomena limit the integration of GeSn alloys on a Si CMOS platform where the thermal budget during fabrication is important. An alternative presented in this work is the use of titanium metallization on GeSn alloy [3].

N-type GeSn layers with 6 at.% of Sn ([P] = 3E19 at/cm^{-3}) were epitaxially grown on Ge-buffered Si (100) substrates in a reduced pressure chemical vapor deposition (RP-CVD) tool. A surface preparation was performed by Ar plasma treatment for 60 s. Then, Ni, Ti and TiN capping films were deposited by magnetron sputtering at room temperature. Various physicochemical characterizations were performed, including AFM, XRD and sheet resistance (R_{sh}) measurements. Transfer length measurement (TLM) structures were fabricated to extract the contact resistivity.

Titanium reacts with GeSn to form a stable Ti-rich alloy (at least up to a certain temperature threshold), which has a low sheet resistance like NiGe(Sn). The study of the annealing of titanium on GeSn (Fig. 1) shows that the surface morphology remains little deteriorated up to 450 °C compared to the Ni / GeSn system.

Square TLM tests were performed for both Ni and Ti contacts. The results of the Ni contact (Fig. 2) show a rather low contact resistivity with a value around 1.4 x 10^{-5} Ohm.cm^{-2} after a 250°C annealing. Above 350 °C, the Ni-based contacts are no longer ohmic. This is probably due to NiGe agglomeration and Sn segregation phenomena [4]. The Ti metallization (Fig. 3) shows interesting behaviour. Thin Ti film has relatively low contact resistivity as deposited (about 1.5 x 10^{-5} Ohm.cm^{-2}), but contact deteriorates sharply at temperatures above 250 °C. 10 nm Ti deposition shows the lowest contact resistivity with a stable trend up to 350 °C. The best value obtained is 8 x 10^{-6} Ohm.cm^{-2} as-deposited. The thick 20 nm Ti layer gives a higher contact resistivity as deposited, but the values decrease with increasing annealing temperature to reach about 1.75 x 10^{-5} Ohm.cm^{-2} at 400 °C.

This study shows that Ti-based contacts are a viable alternative to obtain thermally stable contact on GeSn layers. Other technological levers to achieve stable Ni / GeSn contacts will be discussed.

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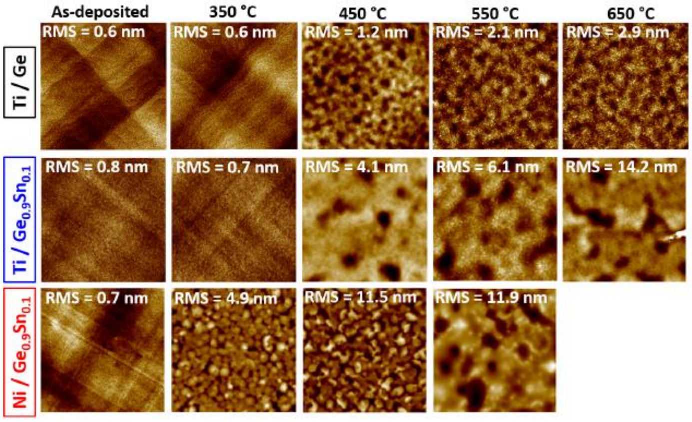

Figure 1: Surface AFM images (scan size 5 µm × 5 µm) of metal / Ge or GeSn samples annealed at various temperatures under N_2 [5].

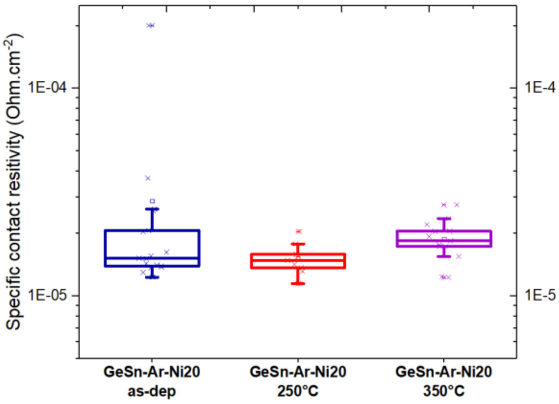

Figure 2: Contact resistivity values obtained from TLM for as-deposited or annealed Ni metallization.

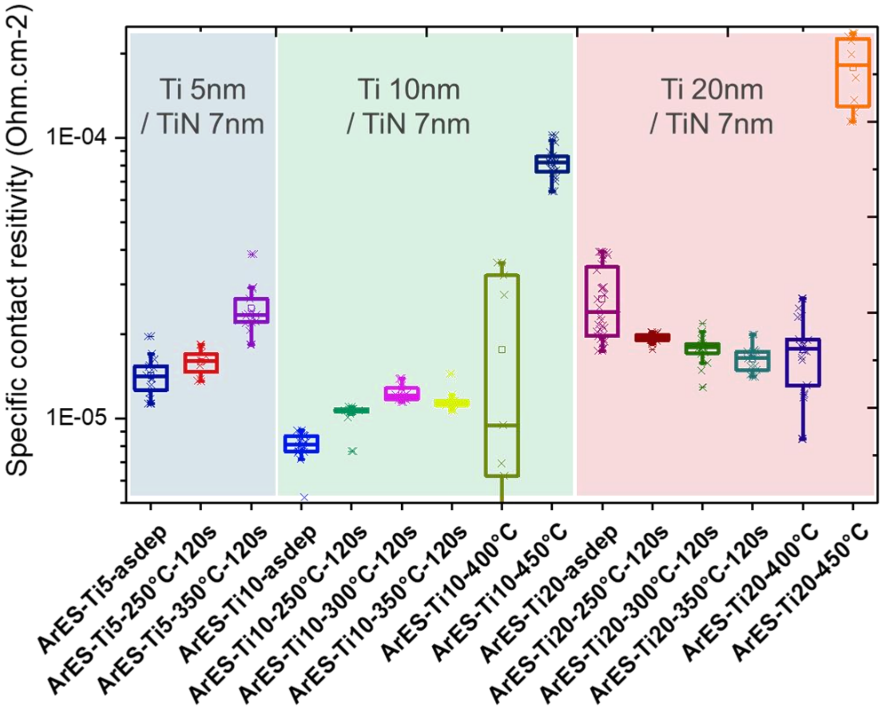

Figure 3: Contact resistivity values obtained from TLM for as-deposited or annealed Ti metallization..