

α -Sn nanostructures with ultra-narrow direct bandgap on Silicon for THz applications

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α -Tin is an allotrope of Sn stable only below 13°C. It is a zero-bandgap topological semimetal with an electronic structure strongly dependent on the strain. It is known that under compressive strain, it exhibits a semiconducting behaviour with a bandgap that depends on the structure and morphology. In this work, uniform thin films of Sn were deposited on silicon and brought to coalesce in nanoparticles with a baking step. The transition from β - to α -phase was obtained at the CNIS-laboratories in Rome via a CMOS-compatible process patented by Sapienza. The process stabilizes the α -phase at room and highertemperature through irradiation with microwaves (MW). The nanoparticles were first analysed by SEM, which determined the size (10-20 nm) and verified an excellent control by the synthesis process over the size of the nanoparticles. Subsequently, FTIR spectroscopy confirmed the presence of the characteristic absorption profile of the semiconducting phase in the MW-irradiated samples. It is supposed that the α -phase is stabilised by the strain due to a combined effect of the size and its Si doping during the MW process. To evaluate the bandgap values, starting from a Tauc-like model holding for 0D structures³, a new fitting procedure was formulated. This approach revealed in all the MW-irradiated samples bandgaps extensions between 20 and 100 meV (depending on the nanoparticle size⁴) and the direct nature of the transition. Those results demonstrate that α -Sn nanospheres stabilised on Si exhibit suitable morphological, structural and electronic characteristics for the development of CMOS-compatible THz sensors and emitters operating in the range 5-25 THz. In conclusion, the simplicity of production, the control obtained over the nanoparticle size, the tunability and extension of the bandgap, the stability above 13°C, open new prospects for α -Sn in THz range as, for example, 6G telecommunications, THz spectroscopy, GHGs monitoring, medical diagnosis, imaging.