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Epitaxial germanium growth and electrical characterization

Matteo Bosi[a], Giovanni Attolini[a], Claudio Ferrari, Cesare Frigeri[a], Enos Gombia[a], Tarik Asar[b], Emine Boyali[b], Suleyman Ozcelik[b], Mehmet Kasap[b]

[a] *IMEM-CNR, Parma, Italy*
[b] Physics Department of Arts & Science Faculty, Gazi University, 06500 Ankara-Turkey

E-mail: bosi@imem.cnr.it

Low bandgap Ge homojunctions are normally used in photovoltaic multiple junction solar cells or thermo-photovoltaic cells and are usually realized by thermal diffusion, starting from an n-type or p-type substrate.
However the diffusion process itself intrinsically precludes the possibility to obtain sharp junctions and to control the doping profile. A better thickness and doping control could be achieved by epitaxial deposition of Ge junctions, with the aim to obtain better photovoltaic efficiencies. Single junction epitaxial Ge cells with high efficiency could find use either in III-V multijunction high efficiency solar cells or in thermophotovoltaic devices coupled to a burner and to suitable selective emitters based on rare earth elements.
The samples presented in this talk were deposited by means of Metal Organic Vapur Phase Epitaxy (MOVPE) on Ge and on GaAs using Iso-Butyl Germane (iBuGe) as organic precursor.
Structures of different thickness were growth by varying the deposition temperature between 400 and 700°C on n and p-type Ge substrates and on GaAs substrate. Arsenic was used as both doping element and as surfactant: in the latter case it was found to improve the epitaxial quality at low temperature. Memory effect of AsH_3 in the MOVPE reactor will be discussed.
Nominally undoped Ge was found to be p-type, while n-type doping is obtained with the use of AsH_3. n/p and p/n junctions were obtained by using a p or n substrate and depositing a n or p type layer, respectively. A completely epitaxial n/p junction on a p Ge substrate was also deposited.
Vertical Ge/Ge mesa junctions were prepared on the above structures by using conventional photolithographic techniques. Ohmic contacts were obtained by evaporation, followed by a thermal annealing at 250 °C for 60 seconds, of Au on the backside of the ptype substrate and by evaporation of Au dots, 400 μm in diameter, onto the n-type epilayer. 500 μm mesa structures, concentric to Au dots, were then prepared by chemical wet etching in a solution of H_2O_2 : H_2O.
I-V, C-V, DLTS and EBIC techniques were used for electrical characterization of the layers. Typical I-V characteristics of the mesa structure show rectification in the range of 10^4, reverse currents lower than 10^{-6} A at 1 V and ideality factor in the 1.008-1.010 range. The good rectifying properties indicate that the nominally undoped Ge layer is n-type. Capacitance-Voltage (C-V) measurements suggest that the doping of the epitaxial Ge layer is expected to be higher than that of the substrate.

Keywords: Germanium, epitaxy, electrical characterization.