As grown ultra-thin MgB_2 films for superconducting detectors

Evgenii Novoselov* and Sergey Cherednichenko

Chalmers University of Technology, SE-41296, Gothenburg, Sweden
*Contact: evgenii@chalmers.se

Abstract**—**For both hot-electron bolometers (HEBs) and superconducting single-photon detectors (SNSPDs) high quality thin superconducting films are of crucial importance. Using MgB_2 with a critical temperature (T_c) of 39K (vs 15-16K for NbN) much higher operation temperatures (15-30K) could be achieved. In this case compact cryocoolers could be used, hence extending missions life time significantly. Furthermore, utilization of MgB_2 for HEB mixer improves gain and noise bandwidths due to shorter electron-phonon interaction time and better acoustic matching to the substrate. Unfortunately, reduction of film thickness is usually followed by reduction of T_c (in 3-5nm NbN films T_c is 9-11K), while for HEBs and SNSPDs a combination of both a small thickness and a high T_c is desirable. Low film roughness and high homogeneity are other importance merits. A hybrid physical chemical vapour deposition (HPCVD) method has been reported to be much more efficient for high quality thin MgB_2 film depositions compared to e.g. molecular beam epitaxy (MBE), co-evaporation etc. It has been shown before than a gain bandwidth (GBW) of 6GHz can be achieved for HEBs made from 15-20nm MgB_2 films. Our goal is to develop a deposition method providing MgB_2 films thinner than 10nm and with a T_c >30K in order to extend GBW to >10GHz.

Here we present our recent results on ultra-thin MgB_2 film deposition using our (in-house built) HPCVD system. To study film properties on submicron level films were patterned in bridges with dimensions varying from $0.3\times0.3\mu m^2$ to $1\times1\mu m^2$. 20nm thick films had a room temperature resistivity ρ_{295K} of $50\mu\Omega\cdot cm$ ($13\mu\Omega\cdot cm$ for un-patterned films) with a T_c of 39K and a critical current density J_c (4.2K) up to $1.2\times10^8 A/cm^2$. A deposition rate of 0.8Å/s is much lower compared to previously reported values (vs 3Å/s). We obtained MgB_2 films as thin as 5-7nm with a T_c of 31-34K, a ρ_{295K} (in sub-micron scale bridges) of $\sim100\mu\Omega\cdot cm$, and a J_c of $(1\text{-}3)\times10^7 A/cm^2$. Using such films antenna integrated HEB mixers ($1\times1\mu m^2$) have been fabricated which showed both a low noise and a noise bandwidth >10GHz (see also "MgB_2 HEB mixer with an 11GHz bandwidth" on this conference).