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Using of radiation technique to transform superconductive NbN thin film to metal or insulator state to form functional nano elements for cryo-electronic devices

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This work describes the way to transform niobium nitride (NbN) superconductive thin film to metal or insulator state under L low energy ion beam irradiation. The radiation technique of selective changing of atomic composition of thin films under ion beam irradiation was designed in NRC Kurchavov Institute and was used for different nano technology applications (patterned magnetic media, metal or insulator nanowires production, etc.). The selective displacement of atoms (SDA) technique was used to displace some of nitrogen atoms in NbN (cubic, a=0.4394 nm) to oxygen atoms under composite ion beam irradiation. As a result NbNO monoclinic phase (P21/c(14), a=0.4977 nm, b=0.50217 nm, c=0.52053 nm, $\alpha=\gamma=90^{\circ}$, $\beta=100^{\circ}$) was formed at 1-2 dpa dose range. This phase characterized with metal-type electrical conductivity at 4.2 K temperature and was used to produce integrated cryo-resistive elements. Metal phase formation was proved by electrical measurements and HRTEM structure analysis. Further increasing of the ion irradiation dose was lead to full displacement of nitrogen atoms to oxygen atoms and initial superconductive film was transformed to insulator amorphous film of Nb_.O_.. The formation of insulator film was proved by electrical measurements, XPS and EELS techniques. Insulator phase was used to form on chip-integrated cryo-nanocapacitor elements. We also used this insulator phase to form the nanoscale gap in planar Josephson junction (SIS) structures. In all cases to implement the ion-irradiation techniques in the field of nanotechnology, the protective mask must be used to get desirable properties transformation in different parts of on-chip design structure. We have developed some protective layers on the top of polymethyl methacrylate (PMMA) electron resist film to increase the radiation stability of the nano-mask during irradiation.

Biography

K E Prikhodko is working in NRC Kurchatov Institute in the field of structure TEM analysis and ion beam irradiation. He specializes in the field of reactor materials science, radiation solid state physics. He has published more than 60 papers in reputed journals.

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