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HIGH-VOLTAGE PICOSECOND-RANGE AVALANCHE SWITCHING OF SEMICONDUCTOR STRUCTURES WITHOUT PN-JUNCTIONS

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The well-known effect of delayed impact-ionization breakdown manifests itself in 100-ps avalanche switching of Si or GaAs diode p+-n-n+ structure that is triggered by a steep voltage ramp [1-3]. Here we report first experimental observations of delayed impact ionization breakdown in Si and ZnSe semiconductor structures that do not contain any p-n junctions.

Si n+-n-n+ structures with the n-base length from 80 to 180 μm, the n+-layers length from 7 to 60 μm, the n-base doping level 1.7·1014 cm-3 and the cross-section area ˜1 mm2 were fabricated. Experimental setup consists of pulse generator, resistive coupler and two 50-Ω high-quality matched measuring lines connected to 20 GHz oscilloscope and allows measuring device voltage and current with accuracy better than 50 ps. 4 kV pulse with 15-25 kV/ns ramp was applied to n+-n-n+ structure and in-series load.

We observe avalanche switching with risetime about 200 ps, residual voltage 300..700 V and current amplitude ˜70 A. These values are comparable to those obtained for p+-n-n+ structures with similar parameters, although the voltage ramp applied to n+-n-n+ structure is much steeper. Numerical simulations indicate quasi-uniform impact ionization in the whole structure volume, whereas switching of diode structures is believed to occur via ionizing front propagation [1]. Successful subnanosecond switching, although to higher residual voltage, has been also observed on ZnSe samples with Ohmic contacts.

Our discovery opens a possibility for ultrafast generation of large volumes of dense electron-hole plasma in semiconductor samples without p-n junctions, which is particularly important for such promising wideband semiconductors as ZnSe and CdS.

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