GaN-based surface acoustic wave devices for optoelectronics

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Large energy gap and resultant optical transparency in a near-ultraviolet visible and ultraviolet range make AlInGaN materials system attractive for applications in visible and ultraviolet optoelectronics. Recent improvements in material quality and contact technology have led to a rapid progress in III-nitride-based devices, such as blue-green lasers, blue, green and amber light emitting diodes, and ultraviolet photodetectors. GaN-based materials exhibit strong piezoelectric effect, which makes them very promising for applications involving surface acoustic waves (SAWs), such as acousto-optic devices, delay lines and filters for telecommunications, and various sensors. In this paper, we present a review of our recent investigations on surface acoustic waves in GaN-based structures and their possible application in optoelectronic devices, such as a guided-wave acoustooptic modulator/deflector and a remote ultraviolet sensor.

We have studied (Al)GaN-on-sapphire structures fabricated by MOCVD technique. First, we investigated SAW propagation in these structures [1]. The SAW velocity dependence on the acoustic frequency and layer thickness has been determined. The analysis of SAW transducer performance and the measurements of the electromechanical coupling coefficient have been carried out. The influence of acoustoelectronic interaction to the SAW attenuation and velocity has been estimated.

We have also investigated the propagation of guided optical waves in (Al)GaN layers [2]. The measurements of effective refractive indices of guided optical waves have been performed, enabling us to evaluate the layer parameters: refractive index and thickness. Next, we have studied the acoustooptic diffraction of guided optical waves on surface acoustic waves [3]. The conditions for diffraction in Raman-Nath and Bragg regimes have been analyzed. The acoustooptic figure of merit for GaN has been determined.

We implemented the GaN-based SAW oscillator [4]. The oscillator frequency shift induced by the ultraviolet illumination has been observed and explained in terms of acoustoelectronic interaction. The dependence of the frequency shift on the optical wavelength exhibited good correlation with the spectral characteristic of the GaN photoconductivity. The long-wavelength quenching of the conductivity has been observed. The oscillator frequency line-widths exhibited considerable differences depending on the origin of the UV source (the Sun versus man-made source).

GaN-on-sapphire structure seems to be very promising for realization of integrated acousto-opto-electronic device modules consisting of light sources, photodetectors, SAW lines, semiconductor devices etc. located on a common substrate. Further efforts should be directed toward achieving this goal.

a)

b)

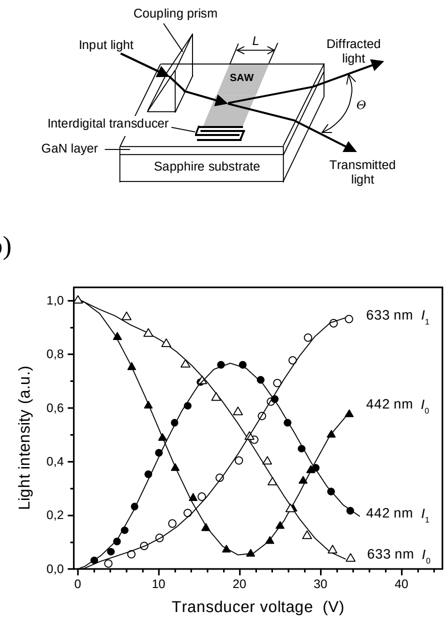

Fig.1. Acoustooptic diffraction: (a) experi–mental arrangement, (b) diffracted light intensity against SAW transducer voltage.

a)

b)

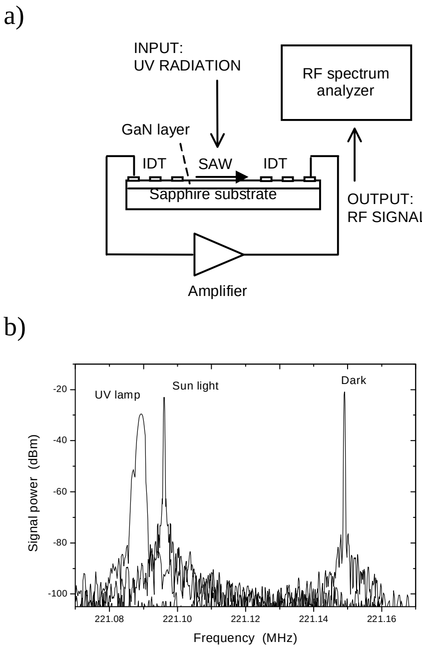

Fig.2. SAW oscillator: (a) experimental arrangement, (b) frequency shift under UV illumination.

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