3P1-24

Proceedings of Symposium on Ultrasonic Electronics, Vol. 30 (2009) pp. 469-470
18-20 November, 2009

Time-resolved imaging of surface acoustic waves on GaAs

GaAs における弾性表面波の時間分解イメージング

Shogo Kaneko†, Osamu Matsuda, Motonobu Tomoda, and Oliver B. Wright
(Grad. Sch. Eng., Hokkaido Univ.)
兼子翔伍†，松田理，友田基信，Oliver B. Wright（北海道大院　工）

1. Introduction

Lowering the temperature of solids in general reduces their ultrasonic absorption owing to the reduction in phonon scattering. In particular this applies to surface acoustic waves (SAWs). Investigating SAW propagation at low temperatures would be useful for deriving accurate acoustic dispersion relations, for example. In this paper we extend a time-resolved SAW imaging technique[1,2] to work with a larger field of view (600 μm × 600 μm) as well as with a larger distance (13 mm) between the optics and the sample, thus facilitating future use of this method in conjunction with a cryostat. This imaging method probes SAWs in the frequency range 100 MHz to 1 GHz.

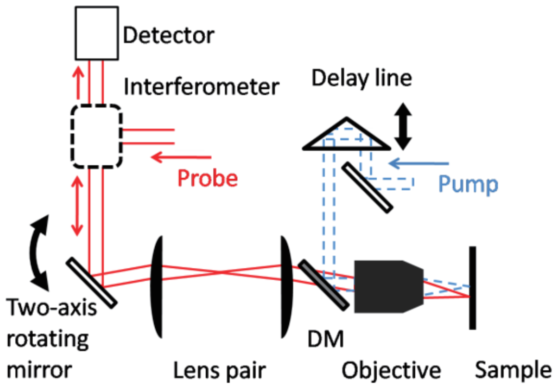

Fig. 1. Schematic diagram of the imaging system. DM: Dichroic mirror.

2. Experimental setup

Fig. 1 shows a schematic diagram of the imaging system. A ×50 microscope objective lens was used in a previous apparatus[1,2] for focusing. However, this is not appropriate for use with a cryostat because of its relatively short working distance <10 mm. We therefore use a ×20 objective which has a 13 mm working distance here.

The optics is based on the pump and probe technique, involving a Sagnac interferometer to detect the SAWs[3]. The probe pulses at central wavelength 820 nm originate from a mode-locked Ti:Sapphire laser at an 80.2 MHz repetition frequency. Second harmonic pulses at wavelength 410 nm are used for excitation (pumping). The pump and probe pulses are focused on the sample surface through the microscope objective lens to a ~5 μm spot diameter on the sample surface. The pump pulses excite ~1 GHz SAW pulses propagating in all directions. The probe pulses interferometrically detect the out-of-plane surface velocity. The probe spot is scanned in two dimensions over the sample surface by means of the two-axis rotating mirror and lens pair. By scanning the delay line, we obtain animations of the SAW propagation. Typically each of these consists of 30 images over a single repetition period of the laser pulses (12.5 ns).

As test samples we use a gold film of thickness 470 nm on a crown-glass substrate as well as a (100) GaAs wafer.

3. Results and Discussion

Fig. 2 shows a snapshot of the SAW propagation on the gold/crown-glass sample at 7 ns after each pump pulse arrival. **Fig. 3** shows an equivalent image for the GaAs sample. The imaging area is 600 μm × 600 μm, which is approximately twice as large as that obtainable with the previous setup[3]. The pump light is focused at the center of the image, and up to 10 concentric rings generated by the periodic pump pulse train are observed. Due to the anisotropy of the sample in the case of GaAs, the wavefront is slightly deformed to a rounded square shape. For both samples the distance between the sample and the edge of the microscope objective is about 13 mm, which is short enough for the future use in conjection with a cryostat.

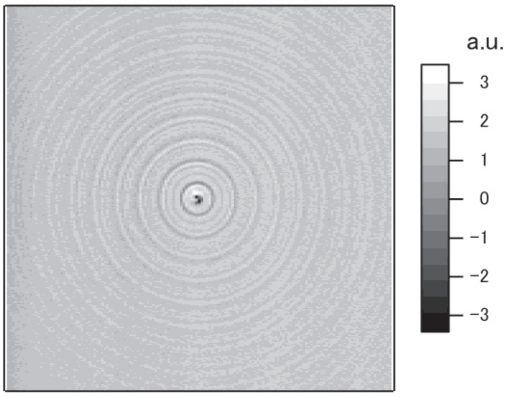

Fig. 2. A snapshot of SAWs propagating on the gold/crown glass sample at 7 ns after the pump pulse arrival. Imaging area is 600 μm × 600 μm.

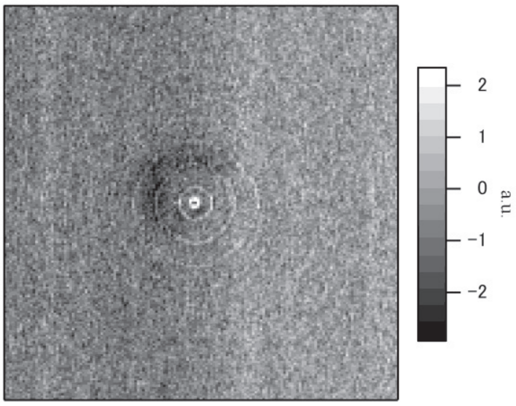

Fig. 3. A snapshot of SAWs propagating on the GaAs sample at 7 ns after the pump pulse arrival. Imaging area is 600 μm × 600 μm.

4. Conclusion

We have constructed an optical setup with a long working objective lens, and have measured the time-resolved propagation of SAWs with a 600 μm × 600 μm field of view. This system promises to be useful for measurements at low temperatures.

References

1. Y. Sugawara, O. B. Wright, O. Matsuda, M. Takigahira, Y. Tanaka, S. Tamura, and V. E. Gusev: Phys. Rev. Lett. **88** (2002) 185504.
2. オリバライト, 菅原美博, 松田理: 応用物理 **73** (2004) 732.
3. T. Tachizaki, T. Muroya, O. Matsuda Y. Sugawara, D. H. Hurley, and O. B. Wright: Rev. Sci. Instrum. **77** (2006) 043713.