SUCCESS STORY

FFG
Promoting Innovation.

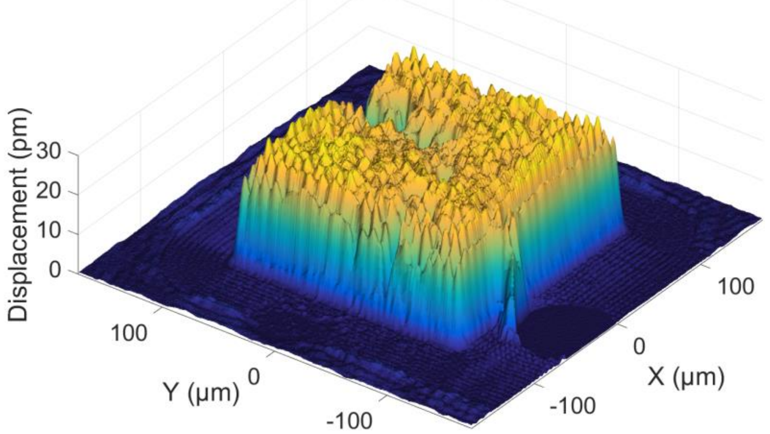
ASSIC
Austrian Smart Systems Integration Research Center

Programme: COMET – Competence Centers for Excellent Technologies

Programme line: K1 COMET-Centre

Type of project: Advanced System Integration Methods, 04/2015 – 12/2018, strategic

ASSIC
AUSTRIAN SMART SYSTEMS INTEGRATION RESEARCH CENTER



Surface vibration pattern of a BAW resonator at 3.1 GHz © CTR

PHOTONIC SUB-ATOM RESOLUTION CHARACTERIZATION OF DYNAMIC HIGH-FREQUENCY MICRO-SYSTEMS

CTR IS NOW CAPABLE OF MAPPING THE VIBRATING SURFACE OF ACOUSTIC WAVE DEVICES (SAW AND BAW) WITH HIGH ACCURACY (< 1 PM!) UP TO 6 GHZ

The next generation of telecommunication standards ("5G") requires new kinds of acoustic wave RF-Filters capable of operating at up to 6 GHz. A method to directly visualize the vibration patterns on the surfaces of the filters would be particularly valuable to directly detect (unforeseen) resonance effects and elucidate complex loss mechanisms. Such an optical research and optimization tool must be able to detect tiny out of plane dis-placements (5 pm to 1 nm) at high frequencies up to 6 GHz, and must be able to scan large areas (> 10 mm2) at a lateral resolution < 1µm automatically within in a few hours only.

CTR developed such a special tool over the last years within the COMET centre ASSIC, applying the Heterodyne Interferometry principle. The beam of a HeNe laser is divided first into two identical beams 1 and 2. Beam 2 is then passed through an Acousto-Optic Modulator, where its frequency is increased by 80MHz, and then used to probe the vibrating surface. The reflection off the surface is recombined with beam 1, yielding a specific frequency spectrum composed of several peaks, including a strong peak at the 'beat frequency' (i.e. 80 MHz), and a smaller peak at the vibrating frequency of the acoustic wave device under test (> 2 GHz). Two photodetectors (one slow, one fast) are used to acquire the signals at these two frequencies. Dedicated, custom-designed electronics, essentially comprising a succession of low-noise amplifiers and a high-performing I/Q demodulation stage, are used to process the signals and extract the amplitudes of the

Federal Ministry
Republic of Austria
Transport, Innovation
and Technology

Federal Ministry
Republic of Austria
Digital and
Economic Affairs

two peaks. The amplitude of the measured vibration can then be deduced from the amplitude difference between the peaks.

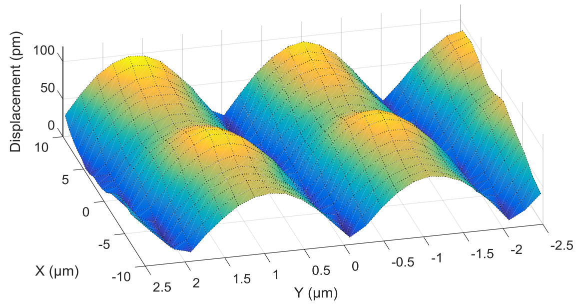


Fig. 1: High-resolution scan of the surface of a 900MHz SAW resonator.

In its present state, the realized laboratory system can automatically scan full surfaces of Surface Acoustic Wave (SAW) and Bulk Acoustic Wave (BAW) devices up to 10mm2 within a standard work day. An outstandingly low detection limit of 0.5 pm (5·10-13 m) of the vertical displacement was achieved, i.e. the tool can detect displacement by less than one hundredth of the diameter of a typical atom. Examples of surface vibration patterns characterized with the tool are shown in the title bar (BAW resonator at 3.1 GHz), in Fig. 1 (SAW Resonator at 900MHz), and Fig. 2 (SAW Reflective Delay Line at 2.45 GHz).

Conducted in a joint effort of ASSICs Areas MST and SYS, in addition to staff expertise in applied photonics and systems design, three Master theses and one half of a PhD were dedicated to the design, implementation and test of the interferometer and the data processing system.

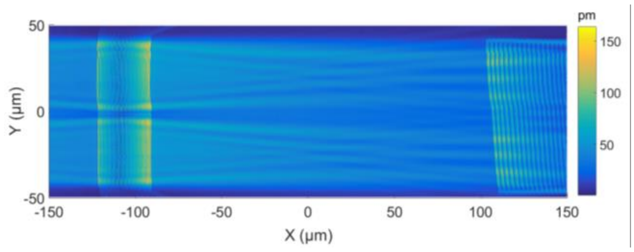


Fig. 2: Acoustic radiation pattern of a 2.45GHz double IDT (on the left), partially reflected by a slanted reflector (right).

Impact and effects

The new tool sustainably enables ASSIC and its host CTR to help partners dealing with SAW/BAW filters, sensors and related devices to directly analyse their designs, understand the origin of various kinds of issues, and optimize new concepts and products in a most effective and efficient manner. Presentation of these first results at the 2018 IEEE International Ultrasonics Symposium in Kobé (JP) caused a wealth of positive feedback and expressions of interest, including applications well beyond its originally intended core application field, helping researchers to e.g. test new ideas and concepts in the exciting fields of phononic crystals and acoustic metamaterials.

Project coordination
Dr.-habil. Pascal Nicolay - Senior Researcher
Project leader
MSc. Hugo Chambon - Junior Researcher
CTR Carinthian Tech Research AG
T +43 (0) 4242 56 300 - 234
Pascal.Nicolay@ctr.at

K1 COMET-Centre ASSIC
CTR Carinthian Tech Research AG
Europastraße 12
9524 Villach
T +43 (0) 4242 56 300 - 0
info@ctr.at
www.ctr.at

Project partner

- RF360 Europe GmbH, Germany