Australian National Fabrication Facility
ACT Node & WA Node
NEWSLETTER
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Enabling On-chip Airborne Multispectral Thermal Imaging

A recent research paper enabled by ANFF-WA, and reporting on the PhD research of Hajfeng Mao from UWA, was selected for its excellent quality as one of the three JMEMS RightNow Papers in the first issue for 2016 of the IEEE Journal of Microelectromechanical Systems (JMEMS), arguably the top journal on the topic of MEMS/NEMS. The distinction recognizes the excellent quality of research enabled by ANFF-WA. The paper reports on the miniaturisation of bench-top microwave oven sized infrared technology onto a chip to enable wide spread accessibility of passive thermal imaging solutions.

State-of-the-art infrared thermal imaging systems capture completely passive thermal images of emitted radiation over multiple discrete wavelength bands of interest within the longwave infrared (LWIR: 8-12 μm) spectral range. Such systems can extract spectral signatures of objects, and thus provide enhanced detection and discrimination of targets in clutter in comparison to single-band imaging systems. The utility of LWIR multispectral thermal imaging systems have been well established in a wide variety of applications, ranging from gas and volatile organic compound diagnostics, mineral mapping, and global atmospheric temperature profile monitoring. Conventional multispectral thermal imagers select spectral bands by means of a series of band-pass interference filters mounted on a motorized filter wheel. This type of configuration, based on standard bulk optics, is characterized by significant size, weight and power (SWaP), which hinder the widespread adoption of the technology in many desirable applications.

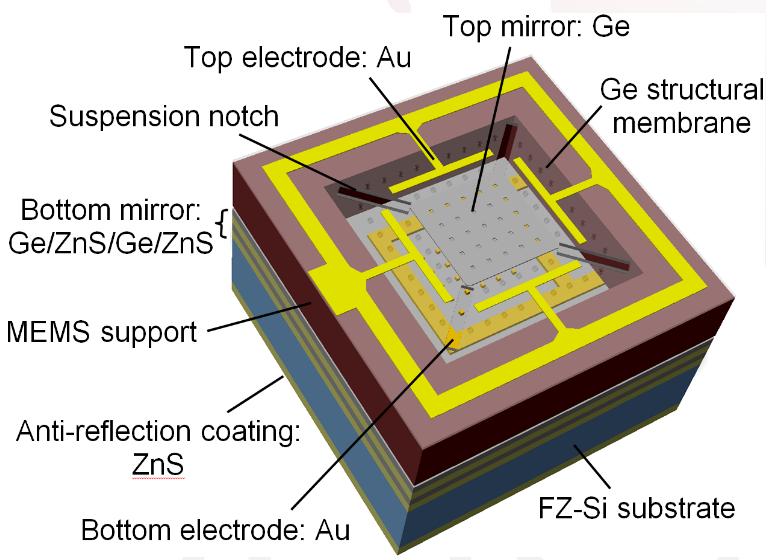

Fig. 1. Graphical depiction of the MEMS-based tunable LWIR Fabry-Perot filter. The top membrane, except for the central mirror region, is drawn semi-transparent for illustration purposes

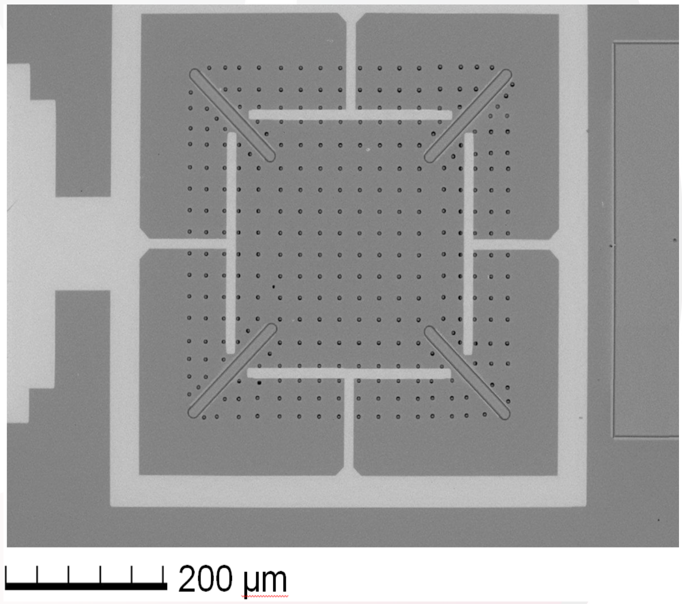

Fig. 2. Scanning electron microscope (SEM) image of a fabricated filter.

Researchers at the Microelectronics Research Group (MRG) at The University of Western Australia have developed a micro-electromechanical systems (MEMS) based on electrostatically tuned Fabry-Perot filter that is suitable for hybridization with a 2-D imaging focal plane array (FPA). Such a module meets the all-important SWaP requirements suitable for field-portable and airborne applications.

The MEMS-based tunable LWIR Fabry-Perot filter (as depicted in Fig. 1) consists of a single-layer Ge as the suspended top mirror, a fixed four-layer Ge/ZnS/Ge/ZnS bottom mirror on a float-zone (FZ) silicon substrate and a single-layer ZnS anti-reflection coating on the backside of the substrate. The top Ge mirror layer extends all the way out to the outer perimeter of the MEMS structural support. Diagonally arranged corner notches serve to release the convergence of tensile film stress from two orthogonal directions, and also reduce the spring stiffness of the membrane and allow actuation at relatively lower voltages. Au electrodes are deposited around the central mirror which, in combination with the underlying bottom Au electrodes on the substrate, serve as the electrostatic MEMS actuator used to vary the position of the top mirror, thus providing a means of controlling the optical cavity length and resulting in transmission wavelength tunability. Over the course of the last few years, UWA PhD candidate Haifeng Mao has demonstrated a prototype device (see Fig. 2) of optical filter tuning performance presented in Fig. 3. The wavelength tuning range of the 200-μm square sized filter was observed to be 8.5-11.5 μm and was obtained using a voltage of 160 V (this high actuation voltage can be reduced by optimizing the MEMS design). This wavelength tuning range accounts for 75% of the complete thermal imaging band of 8-12 μm, and to date is the widest tuning range reported in the literature for a MEMS-based LWIR Fabry-Perot filter. The filter exhibited consistent spectral characteristics over the entire tuning range, including a peak transmission above 80% and a FWHM of approximately

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500 nm. These spectral parameters exceed the optical specifications required for multispectral thermal imaging applications. It is believed that the successful demonstration of this MEMS technology is a firm stepping stone for the future development of miniature multispectral thermal imaging systems based on a hybridized technology incorporating a large-area MEMS-based tunable LWIR Fabry-Perot filters and a large-format 2-D LWIR imaging focal plane arrays. MRG current research work is directed towards the development of a multi-centimeter scale tunable filter that is suitable for hybridization with an imaging focal plane array with a high spatial resolution of 1080 × 1024.

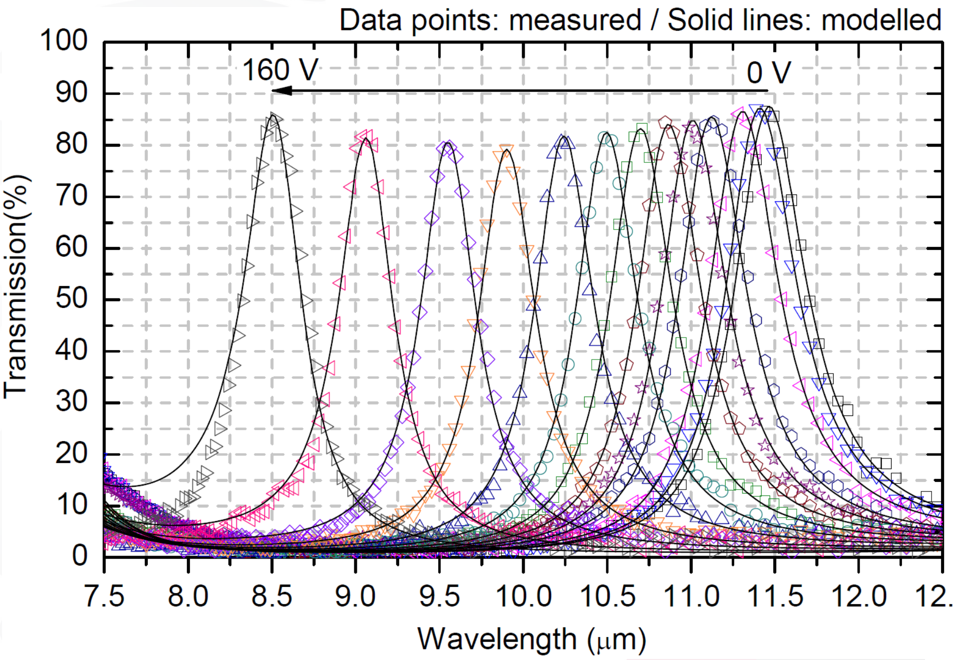
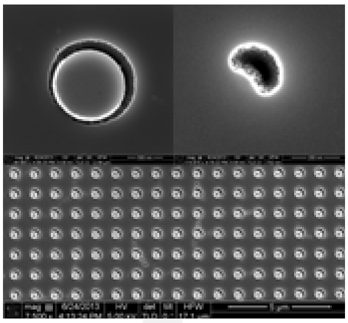


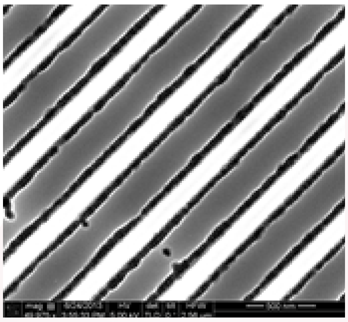
Fig. 3. Transmission tuning spectra of the fabricated filter (data points: measured, solid lines: modelled).

Dual Electron Beam/Thermal Evaporator: Temescal

Continuing our series of articles focusing on tools available at the ACT Node, this quarter we look at another deposition system that is heavily used for metal deposition– e-beam/thermal evaporator. The Temescal BJD 2000, dual e-beam/thermal evaporator system has been running since 2010. The system can process up to five 6” wafers, which means it can handle many microscope slides and other small samples in one run. The system has an extended chamber for a larger distance between source and sample to avoid excessive heating during thick metallisation making the system very suitable for lift-off processes along an increased material usage. The system also incorporates Argon Ion Gun to do sample cleaning prior to deposition or for doing ion –



assisted e-beam evaporation. Cleaning ensures better adhesion of the evaporated film to the substrate, while ion-assisted deposition results in better adhesion as well as dense films. The samples stage is water-cooled, however, should need be, it can be heated up to 250°C with in-built halogen lamps. Sample heating can yield superior film for some metals. Also heating helps in de-gassing the chamber walls, thereby, resulting in faster pumping and better vacuum.



The vacuum component consists of a scroll pump and a cryo-pump allowing for a vacuum range in the mid 10-7 mTorr. Low vacuum reduces contamination and results in highly pure films.
The e-beam source consists of six pockets, so up to six different metal layers can be deposited sequentially. It is capable of depositing up to 500 nm thick films in one run. The system is dedicated for ohmic and Schottky contacts in III-V compound semiconductors. Available metals are: **Al, Au, Cr, Ge, Hf, Nb, Ni, Pd, Pt, Ta, and Ti.** Please note, dielectrics are not allowed in the tool to avoid contamination issues. The thermal source consists of a single boat and is mainly used for depositing thin layer of gold on top of EBL resists to prevent charging during exposure.
Some Tricks: It is well-known that evaporation is highly line-of-sight process, meaning the metal only deposits either on top or bottom of a pattern with almost zero deposition in the sidewalls. Instead of mounting the sample perpendicular to the source – the traditional way, we mount them at an angle to shadow certain regions in the pattern. With this technique known as Glancing Angle Deposition (GLAD), we can fabricate a variety of structures such as trenches and crescents suitable for plasmonics, solar-cells, data storing and bio-sensing. The shadow region can be varied to change the resulting nanostructures by varying the sample-source angle. This is useful to control central-width of a nano-crescent or line-width of a trench.

Welcome to our winter issue

Our Node Admin Ms. Shelly Song decided to concentrate on her study and resigned from her position end of May 2016. Hence we went through a new process of advertisement, shortlisting and interviews. The selection process lead to the appointment of Mrs. Susan (Sue) Berkeley and she started her position on June 23rd. Mrs. Berkeley has long experience within ANU in various administrative roles. Please welcome her warmly. ***Fouad Karouta***

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