NAM6 Nano And Micro Systems

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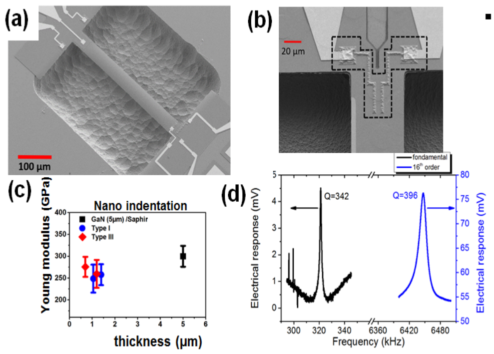
- **Fields of activity:** MEMS and NEMS, resonant devices, advanced cleanroom process, materials/device characterisation, and MEMS/NEMS modelling.
- **Strategic positioning:** Complementarity of technological/scientific—pushed and application-pulled domains. Main topics are: GaN MEMS - MEMS and flexible-stretchable devices - MEMS and NEMS probes for near-field and RF applications - Instrumentation for nano-characterization

GaN Micro and Nanosystems

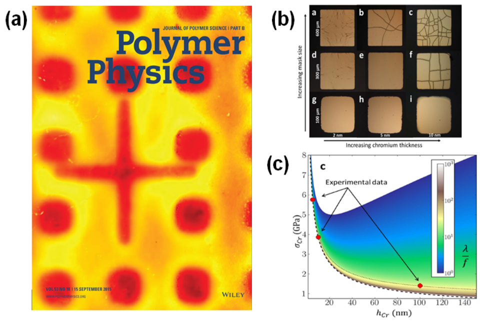
- **Objective**: Sensors working in a harsh environment.
- **Methods**: Use GaN on Si, develop new tranducers based on piezoelectric-2DEG couping in heterostructures.



- **Results**: (a) GaN doubly clamped beam microresonator made on 700 nm epilayers, preparing the NEMS needs for harsh environments force sensors. (b) piezoresistive transducer using the 2-DEG as strain sensor. (c) assessment of the Young modulus showing a high value, a challenge given the very low epilayer's thickness. (d) resonator electrical response validating the first prototype of GaN resonator on ultrathin layers. Coll. Y. Cordier (CRHEA). Supported by labex GANEX.

Novel processes for microsystems and flexible/stretchable electronics

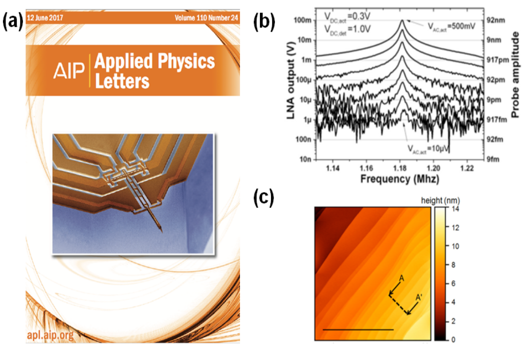
- **Objective**: Stretchable microsystems for life sciences.
- **Methods**: Top-down planar processes and multi-materials deposition on elastomer substrates.



- **Results**: (a) Front cover of J. Polymer Physics : novel photo-hardenable SU-8/PDMS mixture—the red parts are mechanically stiffer than the yellow parts. (b) Evidence that cracking is a size effect in thin metal films on flexible material—thin small metallic features do not crack. (c) Modelling and experimental points of surface stress versus metal thickness.

MEMS Probes for next generation Atomic Force Microscopes

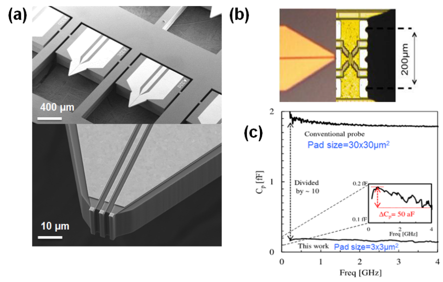
- **Objective**: Sensors for instrumentation at the limit in UHV with Atomic Force Microscope.
- **Methods**: Miniaturize and solve quartz probes issues using a MEMS technology.



- **Results**: (a) Vprobe technology developed by NAM6 and Vmicro SAS. Vprobes combine the highest tip lengh, low impedance transducers, and high f/k ratios. (b) integrated nano-transducers provide a wide range of actuation. (c) first imaging on SiC vicinal surface, scale bar 4.5 µm).

Micro-probes for RF measurements

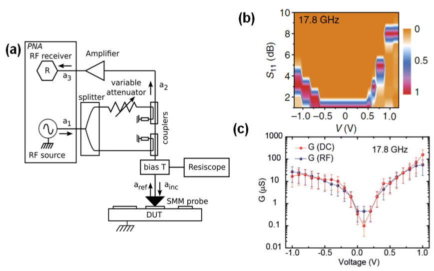
- **Objective**: Miniaturized microwave (GSG) probes for on-chip/on-device
- **Methods**: MEMS design and fabrication using silicon-on-insulator (SOI)



- **Results**: Microfabricated MEMS-based ground-signal-ground (GSG) probes for on-chip microwave measurements. (a) MEMS probes comprising a metallized micro-cantilever–incorporating gold contacts (~2×2µm) and coplanar lines. (b) MEMS probe alongside a commercial µwave probe. (c) evidence of reduced parasitic capacitance when using MEMS probes.

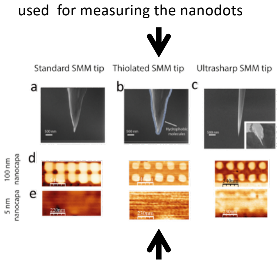
High Frequency instrumentation and application to near field material studies

- **Objective**: Nanoscale electrical characterisation of materials and devices using microwaves
- **Methods**: Coupling AFM and microwave signal applied to the probe tip and developing high sensitivity microwave measurements using interferometry.

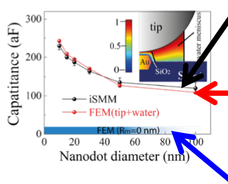


- **Results**: Instrumentation for microwave nanoscale measurements (a) setup coupling a VNA, a home-made microwave interferometer, an AFM and a resiscope (for DC measurements). (b) 2D $|S_{11}|$ histogram (normalized to 1) versus tip bias (V) generated from images of 100 molecular rectifier junctions. The rectifying behavior is clearly observed. (the voltage step is 50 mV and meas. frequency is 17 GHz). (c) Conductance estimated from both d.c. measurement (dI/dV) —red curve—, and S11 parameters —blue curve—. The error bar in log scale is considered to be the same as the full width at half maximum in current histograms.

SEM images of the different probes used for measuring the nanodots



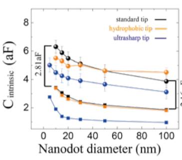
S_{11}-parameter image of 100 and 5 nm Au nanodots measured with the different probes showing the improvement in spatial resolution with probe refinement.



Measured capacitance

Capacitance modelled with water meniscus

Intrinsic capacitance including the tip (with air).



Comparison between intrinsic and modeled capacitance values extracted from measurements after removing parasitics.