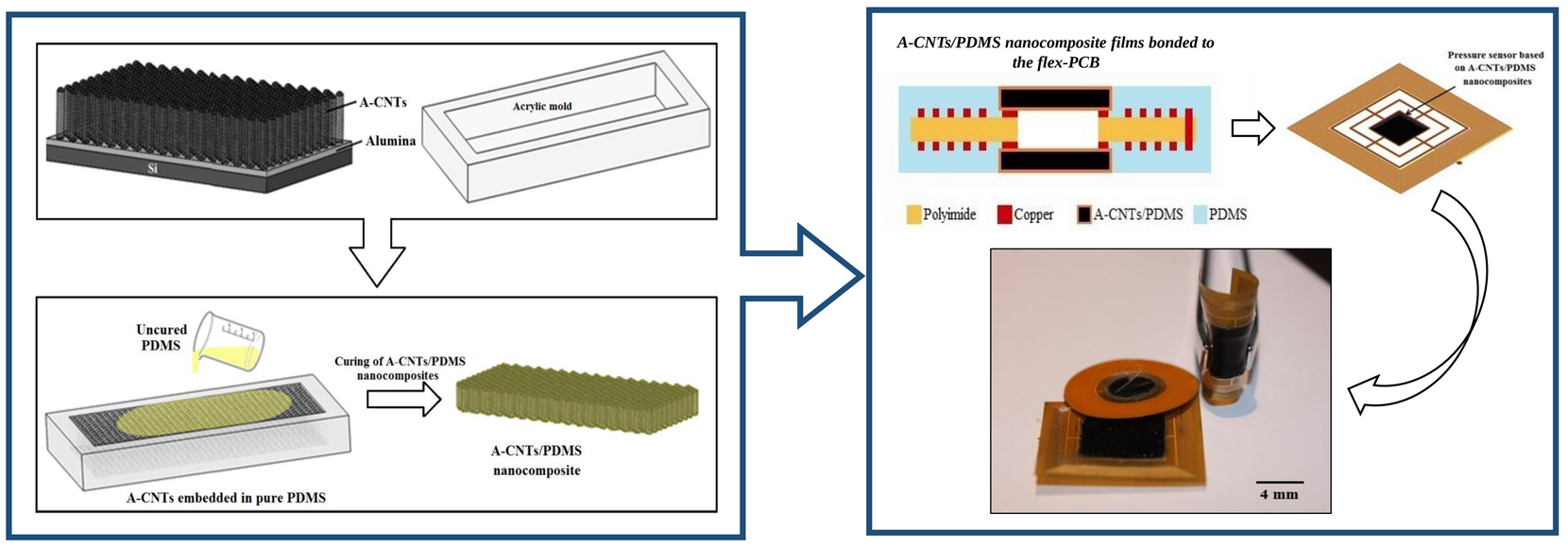
Use of Nanocomposites for Flexible Pressure Sensors



Alexandra T. Sepúlveda, PhD Student

Supervisors: Prof. António Pontes
Prof. Júlio Viana
Prof. Luís Rocha

Objectives

- To develop a fabrication technique to build flexible nanocomposites based on vertically aligned carbon nanotubes (A-CNTs) embedded on a matrix of pure polydimethylsiloxane (PDMS);
- To design and fabricate flexible capacitive pressure sensors:
  - by defining the model of the sensor (mechanical and electrostatic domains) and its telemetric system;
  - by comparing the experimental results obtained for A-CNTs/PDMS nanocomposite flexible capacitive pressure sensors with finite element model (FEM) simulations;
- To study and explore the potentialities of the developed pressure using a particular case study – in the treatment of abdominal aortic aneurysms (AAAs).

Methods and Techniques

I. Fabrication of A-CNTs/PDMS nanocomposite membranes:
  - growth of forests or "carpets" of A-CNTs via an atmospheric chemical CVD process;
  - fabrication of PDMS membranes (dielectric) using acrylic moulds;
  - embedment of the A-CNTs into the polymeric matrix of PDMS, nanocomposite cure and bonding of the three thin membranes (~400 μm);

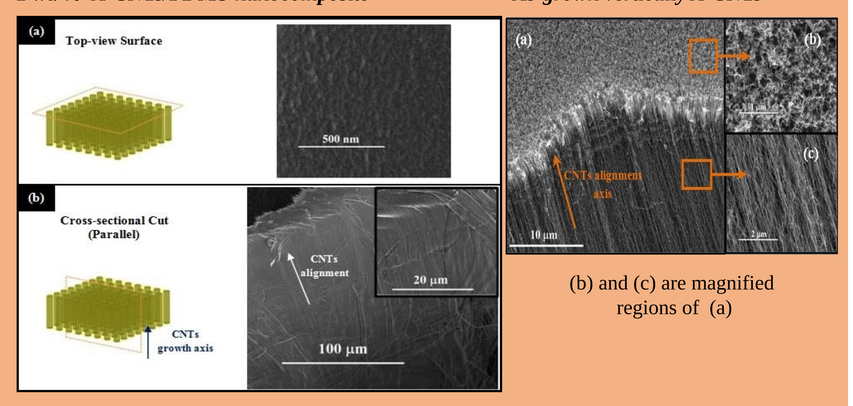
II. Fabrication of flexible capacitive pressure sensors:
  - sensor model, telemetry model and finite element modeling;

III. Morphological, mechanical and electrical characterization.

Results

- Morphological characterization indicates that CNTs preserve its alignment after the wetting process, allowing a controlled manufacturing process;
- Mechanical analysis allowed obtaining for the first time the full constitutive law for transversely-isotropic A-CNTs/PDMS nanocomposites;
- FEM simulations performed using both isotropic and orthotropic material properties compare relatively well, suggesting that isotropic material characteristics are a good approach for modeling the capacitive pressure sensors;
- Static responses of the tested flexible pressure sensors revealed reasonably good linearity in the range of 0-100 kPa, mainly in the region near to the atmospheric pressure;
- Dynamic response of pressure sensors measured in the same range presented two distinct comportments, justified by the viscoelastic behaviour of the PDMS-based nanocomposites used in the pressure sensor.

1 wt. % A-CNTs/PDMS nanocomposite — *As-grown vertically A-CNTs*



(b) and (c) are magnified regions of (a)

Figure 1 – Morphological Characterization of as-grown A-CNTs and A-CNTs/PDMS nanocomposites.

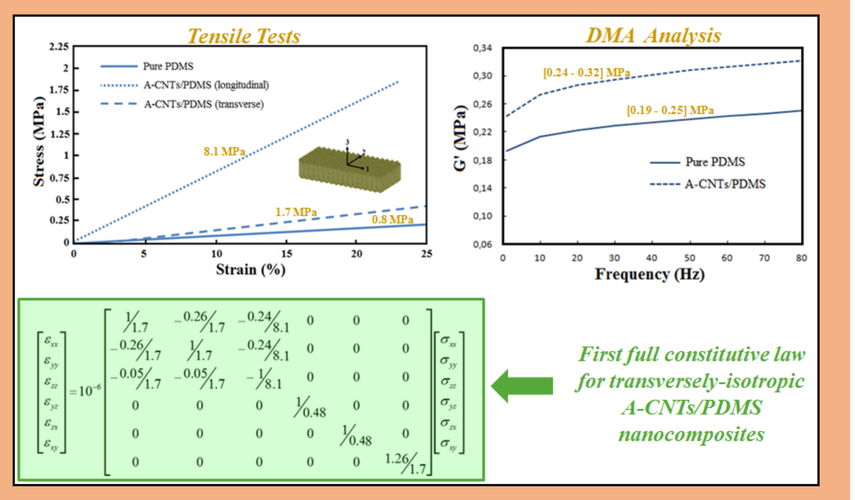
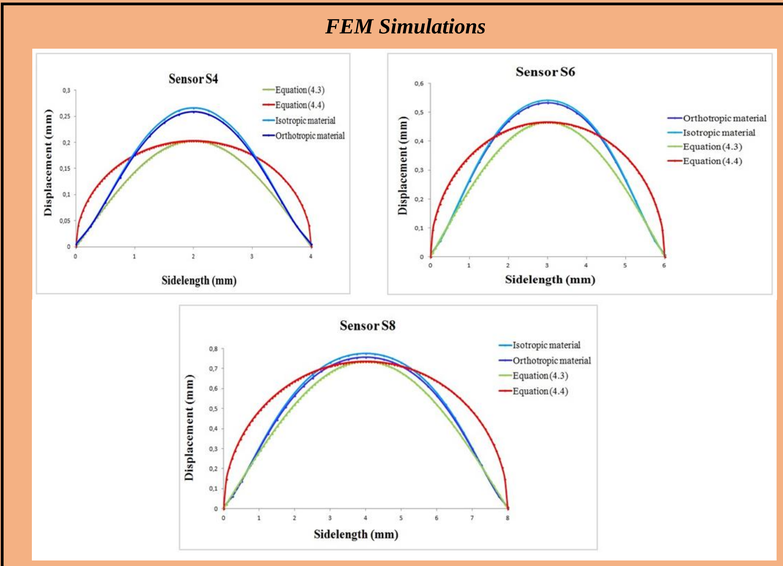


Figure 2 – Mechanical Characterization of pure PDMS and reinforced A-CNTs/PDMS nanocomposites.

FEM Simulations



Capacity and pressure changes measurement

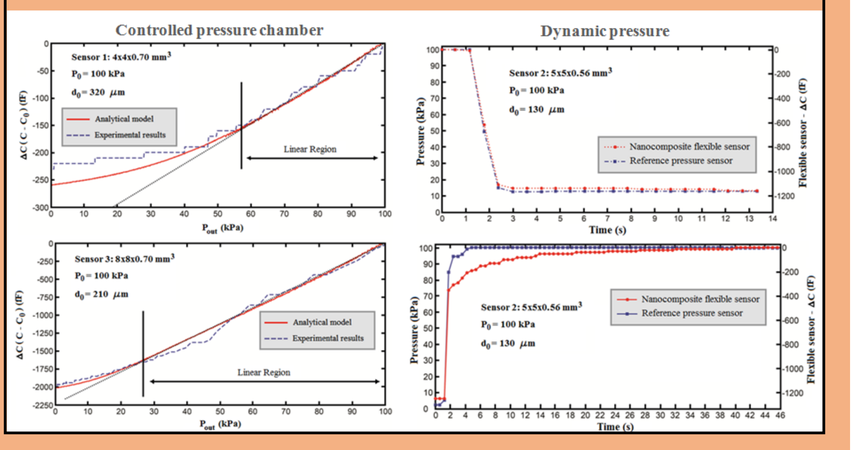


Figure 3 – Characterization of flexible capacitive pressure sensors based on A-CNTs/PDMS nanocomposites membranes.

Publications

A.T. Sepúlveda, R. Guzmán de Villoria, J.C. Viana, A.J. Pontes, B.L. Wardle and L.A. Rocha, "Full Elastic Constitutive Relation for Non-isotropic Aligned- CNTs/PDMS Flexible Nanocomposites", *Nanoscale*, vol. 5, no. 11, pp. 4847-4854, Jun. 2013.

A.T. Sepúlveda, R. Guzmán de Villoria, B.L. Wardle, J.C. Viana, A.J. Pontes, and L.A. Rocha, "Flexible Pressure Sensors: Modeling and Experimental Characterization" *Procedia Engineering*, vol. 47, pp. 1177 – 1180, Jan. 2012.

A.T. Sepúlveda, F. Fachin, R. Guzmán de Villoria, B.L. Wardle, J.C. Viana, A.J. Pontes and L.A. Rocha, "Nanocomposite Flexible Pressure sensor for Biomedical Applications" *Procedia Engineering*, vol. 25, pp. 140–143, Jan. 2011.

IPC – Institute for Polymers and Composites
University of Minho

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