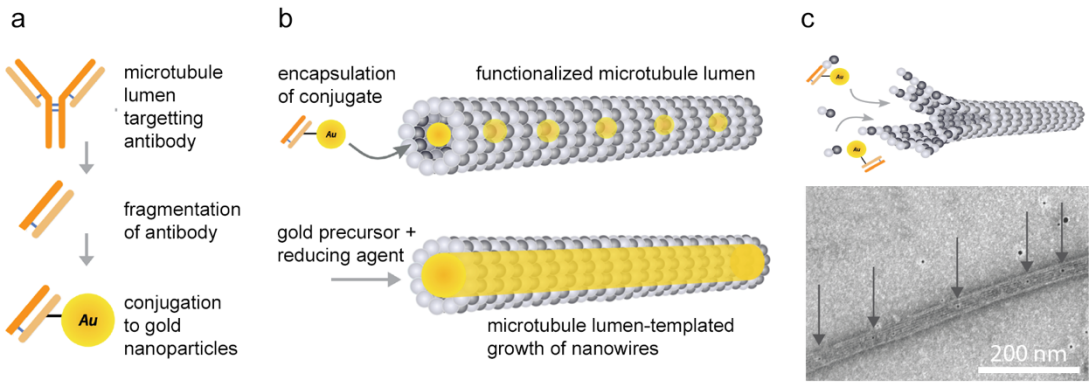
Open PhD Position on
Nanoelectronics with functionalized microtubules
in the Diez Lab

Motivation:
Cytoskeletal protein filaments, such as microtubules, can be employed as regular, high-aspect ratio, cost-efficient templates for the generation of hybrid nanobio-structures. It will be intriguing to explore the applicability of functionalized microtubules as conducting and electronically active nanowires.



Schematics of the approach to encapsulate gold nanoparticles in the microtubule lumen. a) Conjugation of gold nanoparticles to antibody fragments. b) Encapsulation of the conjugates in the microtubule lumen and strategy for the seeded growth of conducting nanowires. c) Transmission-electron micrograph of 5 nm gold nanoparticles incorporated in the microtubule lumen (grey arrows) during microtubule polymerization.

State of the Art and preliminary work:
Microtubules are stiff, hollow protein cylinders with an inner/outer diameter of 15/25 nm and a length of several µm. They can be reconstituted in vitro by self-assembly from tubulin dimers (size of 4x4x8 nm) and can be functionalized with a wide range of chemical and physical markers. In conjunction with motor proteins (e.g. kinesin-1), functionalized microtubules have been demonstrated to be usable for a variety of nanotechnological applications, including optical surface imaging, molecular detection and parallel biocomputation.

Research questions and project aims:
We aim to functionalize microtubules for applications in nano-electronic circuits. Towards this end, we will **generate conducting nanowires by metalizing the lumen of microtubules**. In particular, we will functionalize the microtubule lumen with gold nanoparticles (during or after microtubule polymerization) by conjugating them to lumen-targeting antibodies. Using the microtubule lumen as uniform mold, the encapsulated gold nanoparticles then serve as nucleation sites for the bottom-up fabrication of gold nanowires through electroless gold deposition. In a complementary approach, we will explore strategies to **generate electronic nanowires by functionalizing the outer microtubule surface with metal nanoparticles or customized polymers**. Here, we will conjugate the nanoparticles to microtubule-associated proteins (or peptide sequences) with tunable interaction strengths, such that they can form high density arrays on the outer microtubule surface. Polymers with specific electrical properties shall be linked to tubulin by click-chemistry. The resulting nanowires are envisioned to be applicable as interconnects in nanoelectronic circuits and/or as dynamic sensor platforms. In the future, a combination of inner and outer microtubule functionalization as well as transportung the nanowires by molecular motors is conceivable.