Flexible Carbon Nanotube-Based Strain Gage Sensors

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Abstract: Aging brings about dramatic changes in the skeleton and other organ systems. Major skeletal diseases associated with aging include osteoporosis and attendant fractures (hip, spine and wrist or Collies) and osteoarthritis and its resulting need for various joint replacements. The prosthetic joint market in the United Sates is between $4-5 billion annually and estimates have suggested that this number will increase by upwards of 10% annually as our population continues to age. The average life expectancy of hip and knee replacements is around 10 years, after which replacement of the prosthetic device becomes highly likely. A strain gage sensor that could be incorporated into the prosthetic implant represents a significant advance in terms of assessing the stability of the implant and potentially enables the surgeon to intervene preemptively before failure actually occurs. This poster outlines the fabrication of printable strain gage sensors for use in prosthetic implants and bone biology studies. The authors have completed the preliminary and feasibility studies and are looking for a partner to fund the project. The proposed strain gages are fabricated employing desktop inkjet printers and can be printed on flexible substrates. Special inks based on carbon nanotubes (CNT) and copper nanoparticles are prepared and used in the printing process. The proposed strain gage sensors have several advantages over the conventional metallic alloy gages currently used in biomedical studies. First, CNT-based strain sensors have gage factors of up to 25. In contrast, metallic gages have gage factors of 1.2. The improved gage factors translate into better sensor sensitivity and correspondingly into the detection of smaller strain variations. The commercially available metallic gages have a relatively large size. In contrast, the proposed strain sensors can be made very small due to the fine resolution of inkjet printers and can be custom shaped in different geometries. Furthermore, the sensors can be arranged in arrays

enabling the measurement of strain at different points along the bone or the prosthetic implant. Finally, CNT-based strain sensors have better biocompatibility when compared to the metallic gages. Their biocompatibility has been demonstrated in several studies.

The estimated cost of chemicals and reagents to prepare enough ink to fill several cartridges is around $780. Equipment and lab facilities are available at UMKC. Carbon nanotubes are commercially available from NanoLab Inc. Copper nanoparticles and other chemicals can be acquired from Sigma-Aldrich. A timeline of one year will be needed to fine tune the fabrication process and characterize the strain gages.