TK-5813 (Track: Computer and Information Technology)

Software development for multi-wavelength image correlation

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The National Synchrotron Light Source II (NSLS-II) at Brookhaven National Laboratory offers a large variety of synchrotron based imaging techniques that provide users with structural and chemical information of materials at the nanoscale. Multiple imaging techniques such as light microscopy, infrared imaging and X-ray fluorescence microscopy are commonly used to correlate information from the same sample. Correlating the important information in images presents a large technological challenge because the various imaging techniques generate images of different sizes and spatial resolutions. To overcome this challenge, there are two goals involving software development. The first is to identify a method for using fiducial markers to correlate visible light images with X-ray fluorescence microscope images at the micro- to nanoscale and secondly to develop software for fusion(i.e. overlap) and correlation of these images. Numerous programs were identified to complete this project, such as Matlab, Python, Photoshop, ImageJ and Fiji. After doing much research and testing a variety of these programs, it was clear that Fiji is the best and most efficient program for solving these challenges. It has the capability to align images automatically by converting the image to 8-bit gray scale, finding the maxima (darkest points), and stacking/and/or/corresponding these max points to perfectly align images. Moreover, it has the capability to use manually chosen fiducial point markers where the user inputs landmarks or fiducial points on the image and the program triangulates the points to align them. In addition, I wrote a user manual so that other synchrotron users can benefit from this methodology as well. Overall, this process will prove to be very useful in the future of the laboratory in cases where image correlation is vital. The majority of photon sciences involve correlating images and analyzing the data that come out.

TK-1109 (Track: Humanity and Social Development)

FingerReader

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Visually Impaired (VI) persons number 285 million with 60 million residing in the United States. An estimated 10% of the world's population is dyslexic, numbering around 40 million in the United States population, of which 2 million are students. While the severity of the condition for people with reading impairments varies from individual to individual, they still lack in independence and the proper technology to aid in everyday tasks. When it comes to reading menus, pamphlets, signs and plain texts, we often take for granted the information we process in a single glance: visual layout and design, sentence structure, font size and face, line spacing and many other features.

There are existing solutions by which people with impairments can access printed texts, such as Braille, audiobooks, phone apps and human readers. Blind guides and auditory signals also aid in mobility through the streets. However, the business overhead for developing assistive products is high. Thus, more often than not, people with impairments are left out when it comes to experiencing reading through sight. From tasks such as ordering a meal at a restaurant, catching up on the news from the daily paper, to reading the product label at the store, people with reading impairments often have to ask for help as they are unable to intake this visual information independently. FingerReader aims to give people with impairments real-time, independent access to such visual images.

FingerReader is a wireless finger-worn assistive device that does real-time text-to-audio translation. It utilizes a person's natural scanning motion to read plain texts. FingerReader is worn on the right index finger and provides haptic feedback to guide users along a line of text, vibrating when the user reaches the end of a line or angles their finger incorrectly.

The correct form factor is a crucial aspect of making FingerReader an effective tool. The goal is to make FingerReader an extension of the user's body. Designed with the VI in mind, the ring form factor features simplistic curves that offer fluidity and smoothness to the user experience. The VI interact with the world mainly through touch, thus the device features asymmetrical curves to help minimize the potential of incorrect wearing. To increase the comfort of the device, the curves of the ring band and bezel were designed according to the shape and size of a typical right index finger. Furthermore, the ring band size must be adjustable as finger sizes vary significantly. A spring-loaded clamping mechanism securely fastens the device to the finger to prevent any form of rotation during use. This form factor is also easily injection molded, increasing FingerReader's manufacturability and thus scalability.

The next step is to conduct a user study to verify the effect of the form factor. FingerReader will also expand this text-to-audio technical capability in other markets for people with learning disabilities or who are illiterate. In the future, this technology can also be used as a translation device for language learning.

TK-6100 (Track: Humanity and Social Development)

Interactions Between Gliding Dislocations in 3C-SiC(001)

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Throughout the 20th century there were a number of innovations that contributed towards the improvement of transmitting, recording, and processing information. Perhaps the most important breakthrough of all was the invention of the first transistor by William Shockley at Bell Laboratories in 1947. The downscaling of transistors from about the size of a hand to 7nm has led to the tight packing of millions of transistor on tiny chips that allow for more information to be processed and recorded.

However, one of the most important obstacles to overcome when making transistors at the nano-scale is the emergence of electrically active defects that cause the leakage of current in the semiconducting material. One such transistor that continually suffers from this is the metal oxide semiconducting field-effect transistor (MOSFET), which commonly utilizes the SiC semiconducting material. One of the most common polytypes utilized due to its high saturated electron drift velocity is 3C-SiC. This polytype is a cubic crystal structure composed of silicon and carbon that has a low density of states at the 3C-SiC/SiO interface, making it the most attractive polytype for MOSFETs with a blocking voltage of 600 – 1200V in switching applications.

The 19.7% lattice mismatch at the 3C-SiC/SiO interface causes the formation and propagation of stacking faults (SFs). After the semiconducting material has undergone epitaxial growth, there is an intrinsic stress caused by the presence of the SFs that causes them to expand out of their planes of propagation and in specific orientations. It is believed that leakage current is mainly caused by the intersection of the expanding SFs post-epitaxial growth, forming crowd lines of point defects called forest dislocations (FDs).

In order to fabricate superior transistors so that devices may perform at maximum efficiency, it is crucial that the mechanisms by which leakage current occurs be closely analyzed. Due to limitations in equipment that can accurately measure physical and electrical characteristics of the material at the molecular level, it is necessary to conduct numerical analyses on the formation, propagation, and interactions of SFs. The results of the simulations are validated by the direct correlation between SF density and FD density. In addition, the simulations predict the orientation in which FD lines will most likely form which are predicted to be the dislocation lines along which leakage current occurs. Further study of the generation of FD could lead to more sophisticated fabrication processes of 3C-SiC.

By continuing the study of 3C-SiC and other common semiconducting materials used in a variety of transistors, we will be able to improve the efficiency of electrical equipment. As the world becomes more interconnected it is of paramount importance that we focus on the improvement of the devices that handle information, and the first step is to analyze the issues that are taking place at the molecular level and are decreasing the efficiency of the devices.