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SPECIAL ISSUE: SELECTED ABSTRACTS OF THE V INTERNATIONAL CAPARICA CONFERENCE ON ULTRASONIC-BASED APPLICATION FROM ANALYSIS TO SYNTHESIS (ULTRASONICS 2021)

Acoustically Induced Acceleration of Iron Migration in Silicon Solar Cells

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Available Online: 31 July 2021

ABSTRACT

It is well known that ultrasound (US) can effectively interact with defects in semiconductors. It was experimentally observed that US can cause atomic diffusion[1], transformation of native and impurity defects[2], and annealing of radiation defects[3]. Most acoustically induced (AI) changes in crystal defect subsystem are residual, but reversible AI phenomena are occur as well. The aim of our work is to investigate experimentally the FeB pair association in silicon solar cells under US loading conditions. The n+-p-p+-Si structure was fabricated from a 2 in. (380 μm thick) p-type boron doped Czochralski silicon wafer with a resistivity of 10 Ω×cm. The FeB pair dissociation was made by flash illumination. The short circuit current (ISC) under monochromatic light was used to characterize recombination process in the solar cell base. The iron atom migration energy (Em) was extracted from ISC kinetic after FeB pair dissociation. In the case of US loading, the longitudinal acoustic waves with the frequency of 4.1 MHz, which were excited by using a piezoelectric transducer, were applied to the samples at the base side. The investigation has revealed an acoustically driven reversible decrease in the iron migration energy. The Em alteration value non-linearly depends on US intensity (see Fig.1) and diminishes with temperature decrease. In our opinion, the observed effect is induced by the displacement of impurity atoms with respect to their surroundings. Thus the ultrasound can be effective defect engineering tool in silicon.

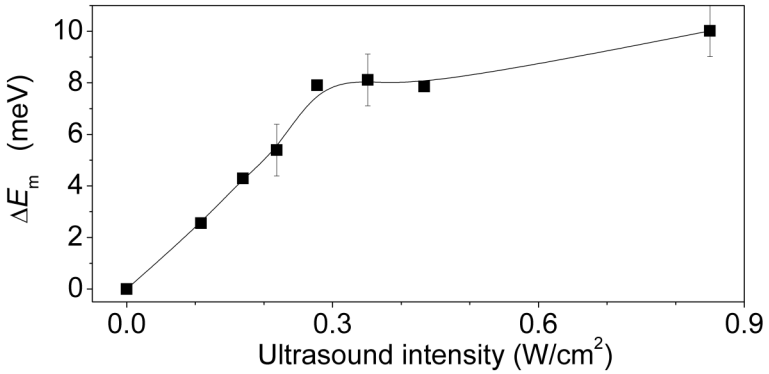

Figure 1 | Dependences of iron migration energy change on US intensity. Temperature of US loading is 340 K.

Keywords: Forensic Anthropology, Forensic Genetics, Paleopathology, Spondyloarthropathies, HLA-B27, SNPs

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Acknowledgments:

The work was supported by National Research Foundationof Ukraine by the state budget finance (project 2020.02/0036 “Development of physical base of both acoustically controlledmodification and machine learning–oriented characterizationfor silicon solar cells”).

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https://doi.org/10.5584/jiomics.v11i1.199

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Machine Learning for Improving Ultrasound-guided Interventional Cancer Procedures

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Available Online: 31 July 2021

ABSTRACT

Our laboratory has been developing 3D ultrasound imaging instrumentation that can be used for a variety of interventional applications. Our approach is to use a motorized fixture to translate, tilt, or rotate the ultrasound transducer with predefined user-controlled spatial and angular spacing. Any manufacturer's ultrasound transducer can be housed in the fixture and images from the ultrasound machine are acquired into a computer via a digital frame grabber. The acquired images are reconstructed into a 3D image as the images are acquired during a 6-10 sec scan. A key factor in making the procedures efficient is to integrate deep learning tools to perform various analysis tasks automatically and almost in real-time. We have developed a variety of these tools and report on two of these.

Prostate segmentation: Needle-based procedures for diagnosing and treating prostate cancer, such as biopsy and brachytherapy, incorporate three 3D transrectal ultrasound (TRUS) imaging to improve needle guidance. Using these images effectively typically requires the physician to manually segment the prostate to define the margins used for accurate registration and targeting. However, manual prostate segmentation is a time-consuming and difficult intraoperative process, often occurring while the patient is under sedation (biopsy) or anesthetic (brachytherapy). We report on the development of a deep learning-based method to segment the prostate in 3D TRUS images from different facilities, using multiple acquisition methods to create a generalizable algorithm for use in needle-based prostate cancer procedures.

Needle segmentation: Purpose: Many interventional procedures require the precise placement of needles or therapy applicators to correctly achieve planned targets for optimal diagnosis or treatment of cancer. Identifying tools in two-dimensional (2D) images can often be time-consuming with the precise position difficult to distinguish. We report on the development and implemented a deep learning method to segment tools in 2D US images in near real-time for multiple anatomical sites, despite the widely varying appearances across interventional applications.

Keywords: 3D ultrasound, Deep learning, Segmentation

Acknowledgments:

The authors are grateful for the funding support from the Ontario Institute of Cancer Research (OICR), the Canadian Institutes of Health Research (CIHR), the Natural Sciences and Engineering Research Council of Canada (NSERC), and the Translational Breast Cancer Research Unit (TBCRU).

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RLS QRD Lattice Algorithm for Hand Detection in Ultrasound-Based Applications

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Available Online: 31 August 2020

ABSTRACT

In this work RLS QRD Lattice Algorithm is used as a new approach of a pre-processing stage for hand detection purposed for ultrasound-based applications. The principle of hand detection in this work is based on noise cancellation technique described in details in [1]. The RLS QRD Lattice algorithm was supplemented with hypothesis testing [2, 3] to improve robustness and accuracy of decision-making while removing undesired responses from the source signal. During experiments, two identification models were constructed. The first regression model has an order higher enough to cover all data coming from the sensor. The second regression model is of a smaller order and with time delay. The settings of the second model are chosen under assumption that it covers the space where there is no hand appearance possible. During estimation process of newly incoming data the algorithm has to choose, which of two models suit best for the given situation. The results of experiments are shown in Fig.1. Due to the algorithm structure, pipelining and parallel processing techniques can be applied. As far as the algorithm is purposed to be mapped on embedded Zynq Ultrascale+ device, it was modified to accelerate computation process [4].

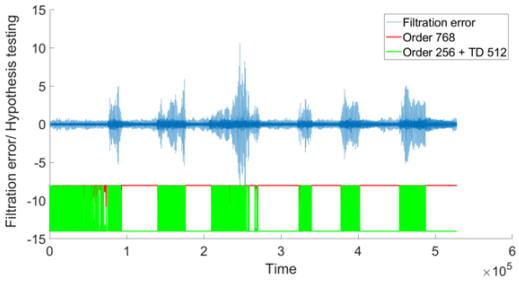

Figure 1 | RLS QRD Lattice algorithm – single precision floating point

Keywords: RLS QRD Lattice algorithm, Hand detection, Noise cancellation, Parallel processing, Pipeling

Acknowledgments:

This work has been supported from project SILENSE, project number ECSEL 737487 and MSMT 8A17006.

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Ensuring Cavitation in a Medical Ultrasonic Cleaner

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Available Online: 31 July 2021

ABSTRACT

Providing a clean and functional medical device is critical to the prevention of nosocomial infection transmission. The use of a medical ultrasonic cleaner (i.e. sonic cleaner) is a major step in the cleaning process to obtain that goal. The cavitation process dislodges debris and remove soil from joints, crevices, lumens, and other areas that are difficult to clean using other methods. It is important to ensure cavitation is occurring in a medical sonic cleaner because if it is not functioning properly, then the unit essentially becomes an expensive soaking tank.

The United States Food and Drug Administration (FDA) classify the ultrasonic cleaner as a Class 1 medical device "intended for cleaning medical instruments by the emission of high frequency soundwaves." ANSI/AAMI ST79:2017 indicates Ultrasonic cleaning equipment is not designed for disinfection or sterilization. Ultrasonic cleaning equipment should be used for fine cleaning, to remove soil from joints, crevices, lumens, and other areas that are difficult to clean using other methods. AAMI recommends cavitation testing be performed daily.

AAMI recommends that medical facility personnel ensure their ultrasonic cleaners are producing cavitation and have the ability to remove a test soil from external and internal surfaces of items cleaned ultrasonically, it is essential to ensure that the verification products used to test ultrasonic cleaners are actually testing for the correct parameters and that the statements made in the testing product IFUs are accurate. Health care facility personnel should understand exactly what these products are testing for, the significance of the ultrasonic cleaner passing the test, and what it means when the cleaner fails the test.

Ensuring that ultrasonic cleaners are working correctly has been a concern for quite some time because there have not been many options for objectively testing ultrasonic cleaners to ensure they are functioning as they should be. Sterile processing team members have had only subjective tests such as the foil test (ie, a piece of aluminum foil is placed into the ultrasonic bath and observed for perforation or destruction caused by cavitation), glass slide test (ie, the frosted portion of a glass slide is marked, placed into the ultrasonic bath, and observed for removal of the mark), and ceramic disc test (ie, an unglazed ceramic disc with a flat finish is marked with pencil, placed into the ultrasonic bath, and observed for removal of the marks). The test results may not always be clear because each of these tests require subjective interpretation. The glass slide and ceramic disc tests demonstrate the removal of soil from a surface, but do not specifically detect cavitation. The foil test detects cavitation; however, the findings of pings and dimples in the foil must be subjectively interpreted by personnel and compared to the original test.

METHODS

A simple test of 4 products side by side using a mason jar containing cleaning solution with no cavitation energy generated. Four Mason jars were filled with 500 mL of utility water mixed with a hospital approved cleaning solution at a dilution of 1/2 oz per gallon of utility water as per the manufacturer's IFU and a temperature of 77° F (25° C). The test was repeated with four Mason jars filled with 500 mL of utility water mixed with the cleaning solution at a dilution of 1/2 oz per gallon of utility water and a temperature of 100° F (38° C). Both tests were repeated three times. The temperature of the solution in each jar was verified by inserting a temperature probe into the cleaning solution immediately before the test products were placed into the jars. The jars were agitated by vigorous manual shaking for 5 seconds once each minute for 15 minutes. The results of the testing products were interpreted according to their manufacturer's IFU and recorded after the 15-minute simulated cavitation process. The 15-minute time frame was chosen because it is the standard time used at the researchers' facility for ultrasonic cleaning of

instruments. Two temperatures were chosen to keep the test design simple. Only one cleaning solution was used. The cleaning solution was diluted in accordance with the manufacturer's IFU.

DISCUSSION

Since ultrasonic cleaning is the combination of mechanical (cavitation) and chemical (cleaning solution) cleaning, being able to distinguish between these different processes and to demonstrate which are occurring and which are not occurring is vital to solving cleaning issues and ensuring effective ultrasonic cleaning of medical devices. Sterile processing and biomedical personnel should understand these different parameters and should know how to test for the components essential to effective ultrasonic cleaning (eg, temperature, cleaning solution, cavitation, cleaning ability). These tests should be part of the facility's quality management program (QMP) where the testing that is performed by facility personnel is known as a performance qualification step. Incorporating a QMP into the facility's ongoing processes for verifying effective ultrasonic cleaning will reduce the risk of patient infection and improve patient outcomes.

The results of this study showed that three of the four products failed to accurately assess cavitation because the dye/soil was removed when there was no cavitation present. These products appear to be sensitive to temperature and the presence of a detergent. It is likely that the longer the product remains in the solution, the more opportunity there is for the dye/soil to be removed from the coupon. Product A, which is enclosed in a sealed, fluid-tight system is not affected by its surroundings unless there is cavitation present. Product A was the only product shown to demonstrate the absence of cavitation and was the product in use at the researcher's facility. This study corroborated that the correct product was being used.

CONCLUSION

Cavitation is an important and necessary function of all ultrasonic cleaners and is the reason these units are so important for effective cleaning of medical instruments. This study was conducted to identify a method to verify cavitation testing of several products designed for this purpose and currently available on the market. The Mason jar method described in this study provides a simple method for simulating an ultrasonic bath where no cavitation is present. The results of the study clearly demonstrate that even when no cavitation is being produced, some of these tests will provide passing results. Therefore, those tests do not distinguish between cavitation production and the other parameters in an ultrasonic cleaner.

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Process intensification of chemical processing applications using cavitational reactors: design, scale up and applications

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Available Online: 31 July 2021

Extended-Abstract

Cavitational reactors are a novel and promising form of multiphase reactors, based on the principle of release of large magnitude of energy due to the violent collapse of the cavities. Use of cavitational reactors for process intensification of several chemical and physical processing applications has been exploited worldwide in recent years. The present work elucidates an overview of design and operation of cavitational reactors also focusing on the different areas of applications in the area of chemical processing illustrating some typical case studies.

The effects of cavitation phenomena as the generation of free radicals, intense turbulence and liquid streaming are the main driving force for the observed intensification of chemical processing applications. It is important that depending on the application in question, the controlling mechanism is identified and then the design and operating parameters adjusted[1] so as to maximize the intensification benefits. For example, for the applications limited by mass transfer it is important to maximize the physical effects of cavitation such as turbulence and acoustic streaming whereas for applications dictated by the intrinsic chemical kinetics, radical formation is most important. Bubble dynamics analysis can be effectively used for the prediction of the cavitational intensity in the reactor and also for the prediction of the best required conditions of the optimum design and operating parameters for dominant physical/chemical effects. For the sonochemical reactors, ultrasonic power dissipation, frequency and duty cycle are the important parameters whereas for hydrodynamic cavitation reactors, inlet pressure/speed, geometry of the cavitating device and the flow rate govern the cavitational effects. In addition, the operating parameters like temperature, pH, presence of gases or solid particles and catalyst loading also govern the extent of intensification obtained due to the use of cavitation.

Different designs of sonochemical reactors applied in the literature mainly include ultrasonic horn, ultrasonic bath and flow cells. The main types of hydrodynamic cavitation reactors include the orifice plate/venturi setup, high speed homogenizer and vortex diode. Comparison based on the two criteria of energy efficiency and cavitational yield estimations for different applications have generally shown favorable results for the hydrodynamic cavitation reactors. Combination of different reactors or operating strategies also at times aid synergistic results. For scale up of sonochemical reactors, multiple transducer, multiple frequency configuration is the best choice whereas for hydrodynamic cavitation, orifice plate/venturi based setup offer promise based on the flexibility in controlling cavitation effects in cost effective manner. Cavitational reactors do find application at large scale and a successful commercial installation applied for treatment and recycle of frac water in oil and gas explorations was demonstrated by Gogate et al. [2]. The reactor is based on the combined usage of hydrodynamic cavitation, ultrasound and

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ozone giving synergistic results and has been successfully used for processing of the recycled fluids at commercial sites on over 1200 oil and natural gas wells during hydraulic operations. The reactor also has promise for number of other applications including the cooling water treatment, lake clean up, municipal waste treatment and also industrial effluent treatment especially for the pharmaceutical, dye and pesticide industries where the conventional methods often show limited efficacy.

Two specific important applications where commercial scale applications are very promising include crystallization and wastewater treatment. The specific advantages obtained using ultrasound in crystallization include ease of nucleation, tailoring the size distribution (Figure 1), obtaining particles with lower mean size and higher crystallinity as well as speeding up the crystallization process. The parameters such as ultrasonic power, time, duty cycle can be effectively adjusted to get the desired particle size distribution. The application in wastewater treatment basically includes enhancing the efficacy of commonly applied biological oxidation. Developing combined treatment schemes is the need of the hour to tackle the highly loaded effluents often seen in speciality chemical industries. For example, Thanekar and Gogate[3] demonstrated the effective application of hydrodynamic cavitation in combination with other oxidation processes yielding the desired COD reduction. The pretreatment of HC+Fenton process followed by conventional biological oxidation resulted in COD reduction of about 98% (final COD ≤ 250 mg/L), which meets the discharge water compliance (Figure 2).

Overall it appears that considerable economic savings is possible by means of harnessing the spectacular effects of cavitation in chemical and physical processing.

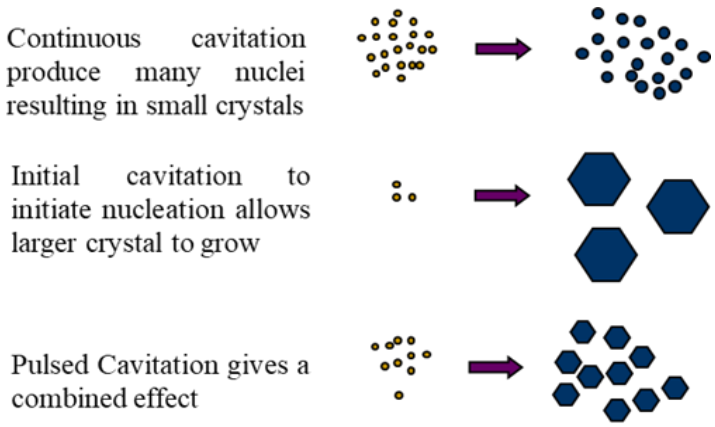

Figure 1 | Controlling size distribution in crystallization using cavitation

Keywords: Reactor Designs, Operating parameters, Chemical processing, Process intensification, Scale up

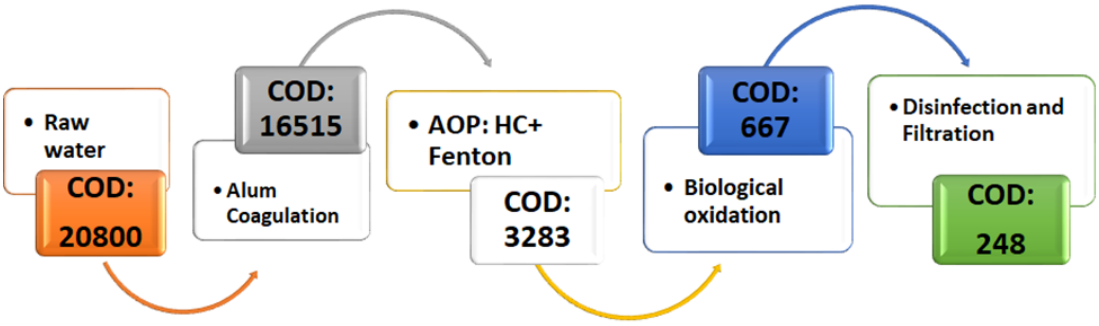

Figure 2 | Combined oxidation processes applied to real industrial effluent

Acknowledgments:

Authors would like to acknowledge the funding of Department of Science and Technology, India, University Grants Commission India and Mangalam Organics Limited, India for some of the research work demonstrated in this talk.

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