NEW MATERIALS FOR PHOTOVOLTAICS

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COLLABORATORS: Arthur Mar, Steve Bergens, Karthik Shankar and their teams; Quantiam Technologies, Michael Fleischauer (NRC Edmonton)

INTRODUCTION

SUNLIGHT - SOURCE OF ALMOST UNLIMITED POWER

More energy in the form of sunlight hits terrestrial earth in one hour than is used by humanity in an entire year. The prairies are particularly rich in solar illumination; southern Alberta, Saskatchewan, and Manitoba have the best annual ins*ol*ation statistics of the entire country ('sunshine'), as shown below, and thus sunlight in the prairies represents an enormous, almost entirely untapped energy resource.

This program looks to identify new materials for the capture of solar energy, and conversion to usable forms (electricity, chemical fuels). In this program, we look to discover materials made from earth-abundant elements for solar energy capture that have very low energy requirements for processing, enable high-throughput and large-scale (scalable) manufacturing processes, including roll-to-roll printing, spray-coating, and others.

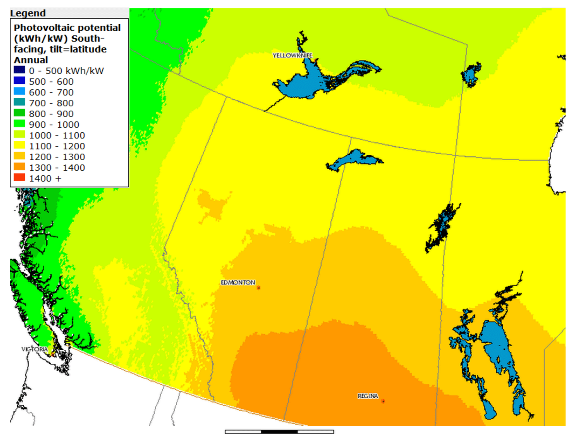

Figure 1. NRCan map of PV potential of western Canada.

SHORT-TERM OBJECTIVES

INTEGRATE the earth-abundant compound, zinc phosphide, with transparent conductors and demonstrate use in a functioning solar cells.

SCREEN HIGH SURFACE AREA transparent electrodes for use in organic photovoltaics. Will they permit the use of mismatched mobility donor-acceptor pairs in organic photovoltaics, thus opening the door to never-before-tested combinations of existing materials?

DISCOVER new silicon surface chemistries to stabilize solar cells in photo electrochemical cells, and to tailor and control electronics for new PV applications.

ACCELERATE the screening of conditions for processing of organic solar cells with machine learning. Learn from past processing conditions to dramatically increase rate of device optimization.

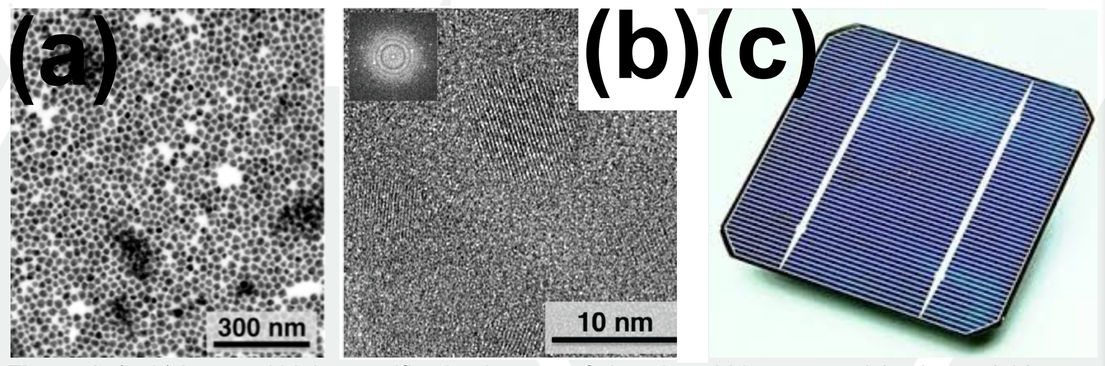

Figure 2. (a+b) Low and high magnification images of zinc phosphide nanoparticles in a soluble 'ink'. (c) Examples of the silicon surface chemistry to tailor the electronics of silicon. (d) Photograph of a commercial silicon PV device (Wikipedia).

PROJECT OVERVIEW

MATERIALS TO CAPTURE AND TRANSFORM SOLAR POWER INTO USABLE FORMS

The key component of any device that captures and transforms solar energy into a useable form is the absorber; the absorber must effectively absorb the broad spectrum of photon energies from the sun, and cleanly convert them into charges that can be extracted. Commercial solar cells are based upon silicon, cadmium telluride, or an exotic combination called CIGS. Silicon solar cells require 2-4 years of operation to break even with respect to energy - the conversion of sand-to-silicon is one of the most energy intensive materials conversion process in mass manufacturing - and CdTe and CIGS comprise at least one rare element, preventing widespread deployment. In this project, we are developing new earth-abundant nanomaterials for PV applications that can be processed via low-temperature processing (roll-to-roll printing, spray-coating of nanoparticle-based inks, low-temperature crystal growth, etc.). Novel materials being developed include both organic polymers and molecules, and inorganic compounds comprising known phases of iron, nickel, zinc and silicides that have high absorptivities that have not been examined for PV. New leads are also under development by collaborator, Arthur Mar and his group, using high-throughput/materials genomics approaches. The outcome of this project will be a family of prototype PV devices, produced from new earth-abundant nanomaterials, that are processed and integrated into devices via low-energy, low-temperature methods - a "one-month solar cell".

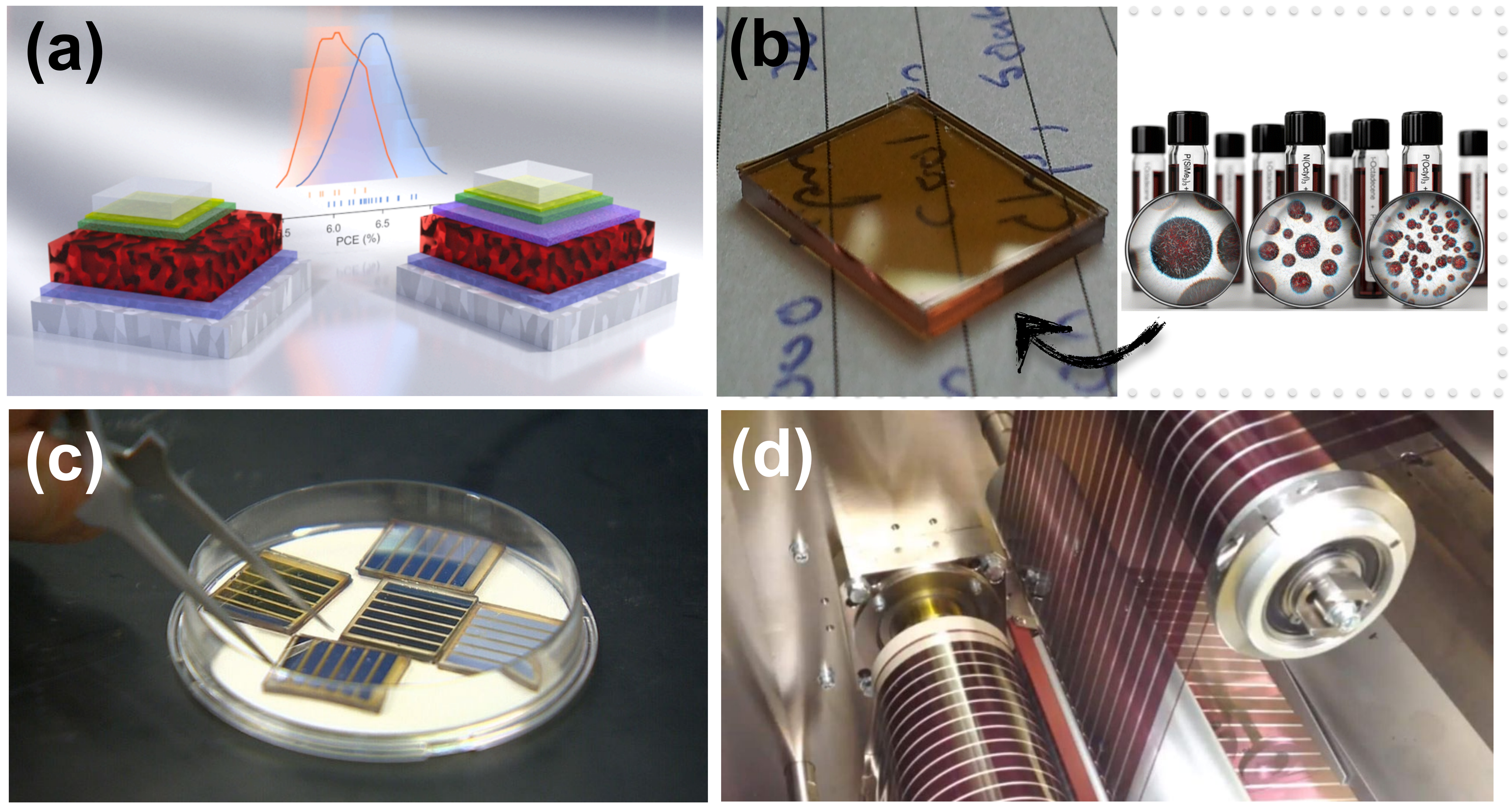

Figure 3. (a) Schematic of a third generation solar cell - made up of sandwich-like layered architectures. (b) Development of zinc phosphide nanoparticle 'inks' for solar cells. From lab-scale to large-scale manufacturing: (c) Small prototype solar cells from the Buriak solar labs. (d) Example of roll-to-roll printing of organic solar cells (www.herox.com)

OVERVIEW OF MATERIALS FOR PHOTOVOLTAICS

TAPPING THE SOURCE OF ABUNDANT, RENEWABLE ENERGY

The sun powers our planet, and has since the dawn of the solar system, providing warmth, light, and energy for countless forms of life. Technologies have made it possible to use energy from the sun to produce electricity and fuels, but new refinements will allow us to diversify the ways in which solar energy can be generated, stored, and utilized later (at night, when it is cloudy). By identifying materials that require little energy to process them for use in the construction of solar cells, finding new catalysts to convert solar energy into chemical fuels, identifying more efficient methods for market integration, and considering the possibility of solar-derived hydrogen fuels, it will be possible to tap this vast energy resource, the most abundant available to humanity, at a scale to power the planet and its soon-to-be 9 billion inhabitants.

ANTICIPATED OUTCOMES

DISCOVERY of new materials for conversion of solar energy into electricity and solar fuels.Through the use of materials genomics (high throughput computational screening) with our collaborators, screening of databases of known materials (but untested for PV applications), and building upon our existing repertoire of earth-abundant materials, a palette of new compounds for solar energy conversion will be formulated.

DEVELOP AND SCALE these new materials. The newly discovered materials should be processable by low-temperature, scalable mass-manufacturing approaches. The materials will be inorganic, earth-abundant 'ink-based' compounds, and organic molecules and polymers, that we render into soluble form that can be spray-coated, and printed via roll-to-roll processes. The newly discovered materials will be converted into nanoparticle-based solutions that can be painted and easily processed.

INTEGRATION of solar energy conversion with storage, via development of materials and catalysts for the splitting of water into hydrogen [H_2 (g)], and reduction of CO_2 (g) into light hydrocarbons and alcohols.

TRAINING of the next generation of highly qualified personnel in the area of renewable/solar energy development.

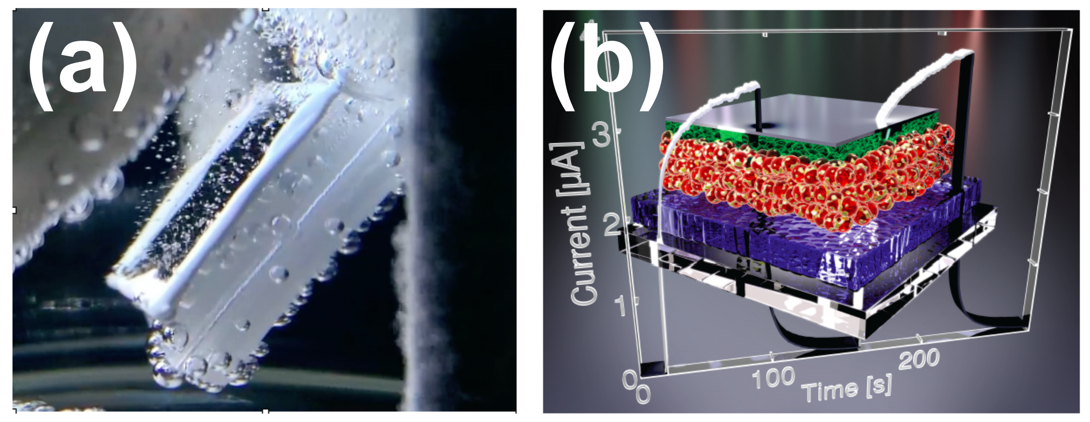

Figure 4. (a) Triple junction amorphous silicon solar cell splitting water to hydrogen and oxygen gas. (b) Schematic of a nanoparticle-based, solution-processed solar cell. Nanoparticles represented by the orange layer.

EXTERNAL PARTNERS

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