Nano+Nuclear Batteries

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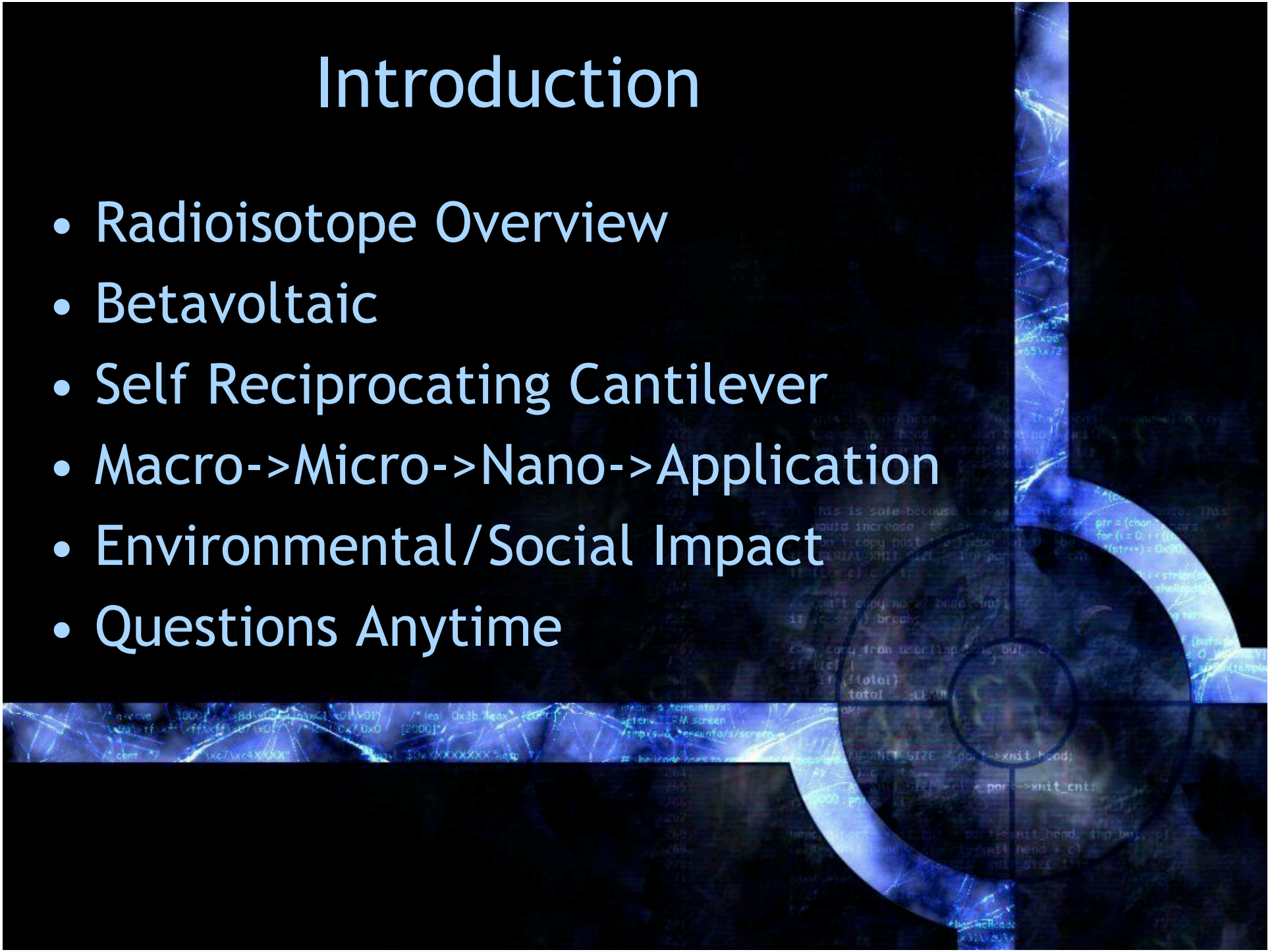
Introduction

- Radioisotope Overview
- Betavoltaic
- Self Reciprocating Cantilever
- Macro->Micro->Nano->Application
- Environmental/Social Impact
- Questions Anytime



Nuclear Battery?

Goal: Convert energy from radioactive decay to electricity

RADIOISOTOPE FUEL

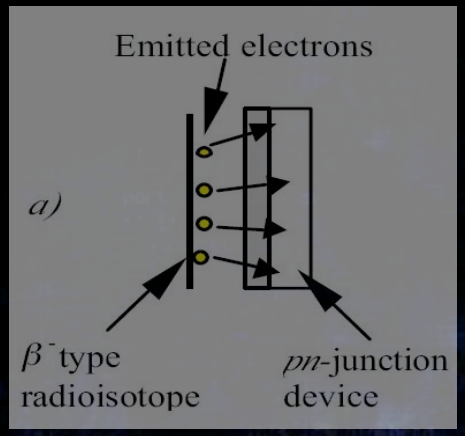
- Type of radiation
  - –Alpha
  - –Beta
- Half-Life

  Long -> Long battery life
  Short -> Higher power

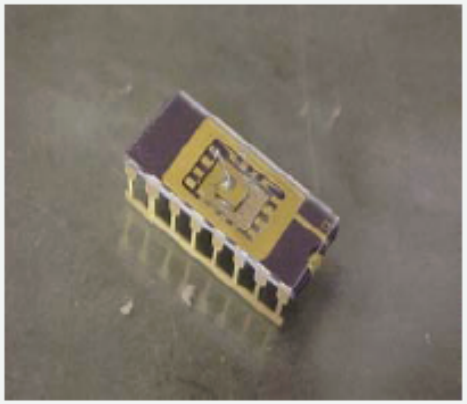
Consider 1 mg for power source	
Source	Energy Content (mW-hr)
Chemical Battery (Li-ion)	0.3
Fuel Cell (methanol, 50%)	3
210-Po (5% -4 years)	3000
3-H (5% -4 years)	500

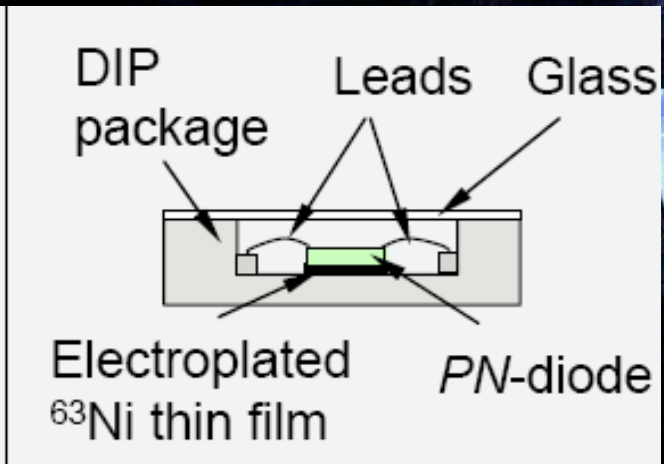
Betavoltaic Batteries

- Direct Conversion pn-Junction Type
- Radiation Energy Used to Create Electron Hole Pairs (EHP) Near Junction
- EHPs Diffuse into the Depletion Region of the Semiconductor *pn*-Junction
- Resulting Current is from *n*- to *p*-type semiconductor
- Net Power Can be Extracted



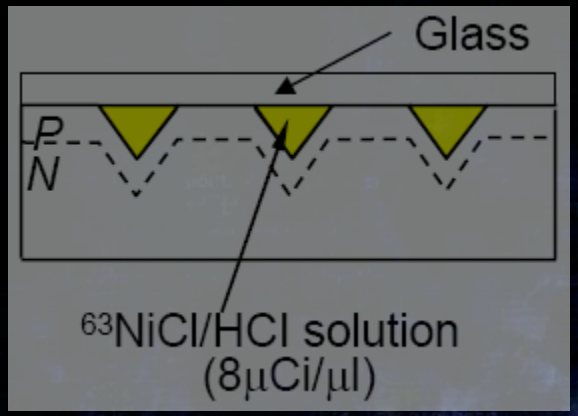
- 0.04~0.24nW Nanopower
- 0.1~0.3% Efficiency
- No Performance Degradation After 1 year



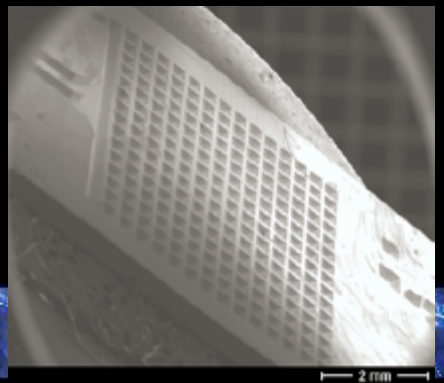


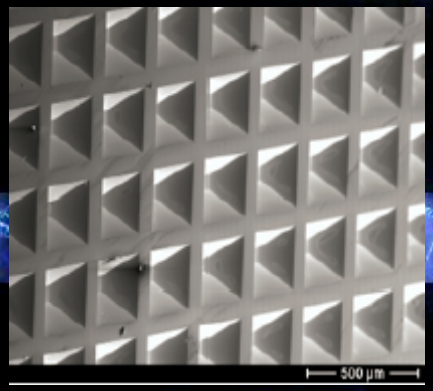
Inverted Pyramid Betavoltaic

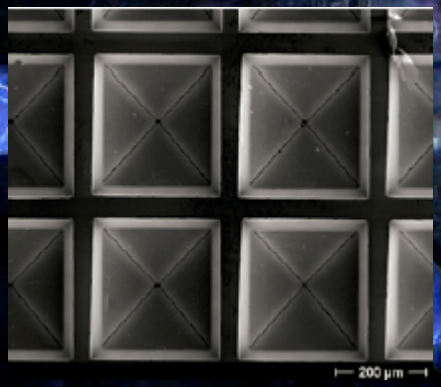
- Increased pn-Junction Area-> Increased Depletion Region
- Liquid or Gas Solute Source



•0.32nW (128mV/2.86nA) obtained

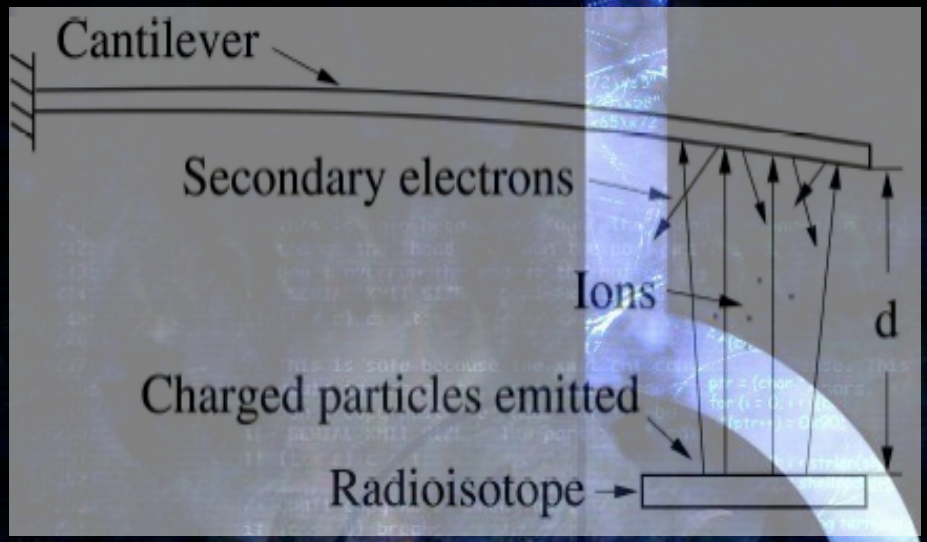


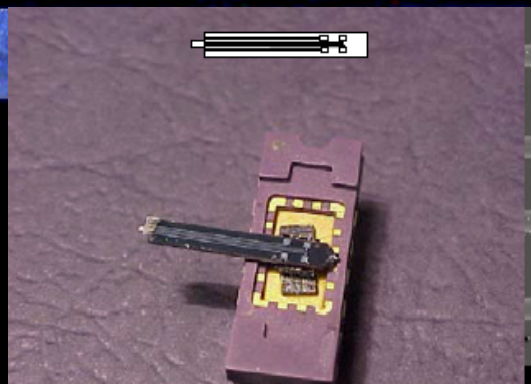


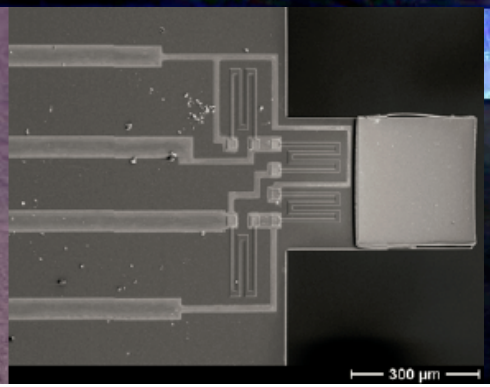


Self Reciprocating Cantilever

- Ionizing Radiation Accumulates Charge On Cantilever
- Leads to Attractive Force
- Beam Discharges When Close or On Contact
- Resulting Movement is a Periodic Charge Integrator







Scaling Down to Nano

- Long History of Nuclear Battery Use
- Currently No Nano-Nuclear Batteries
- Nuclear Physics Works on Nano-scale
- Limited by Ability to Nano Fabricate
- Research Driven by MEMS Application
- Major Funding by Military
- Consumer Electronic Application?

Environmental/Social Impact

"AAAAAAAAAAA" Battery

- Viable Power Source for MEMS and Similar Systems
- Recycle Nuclear Waste
- Aren't Cheap

Radiological

- Small Dose
- Increase in the Probability of Exposure

Question?

- Thanks to James Blanchard, Hui Li, Amit Lal, and Douglass Henderson for Borrowed Pictures