Homebrew Piezoelectric Crystal
(Potassium Sodium Tartrate, also known as, Rochelle Salt)

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Engr. 45, Fall 2011
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What are Piezoelectrics?

- Materials with piezoelectric properties produce an electrical charge when mechanical pressure is applied.

- Interestingly, when the mechanical pressure is reversed (from compression to tension) the sign of the electric charge change.

- Piezoelectric materials will also expand if you send an electrical charge through it.

- Their applications include using them in speakers, ultrasonic imaging, rocket propelled grenades, light up shoes, and watches.
Materials with Piezoelectric properties

Crystals (natural)
- Quartz
- Rochelle Salt
- Topaz
- Sucrose (table sugar)

Ceramics (man-made)
- Barium titanate ($\text{BaTiO}_3$)
- Lead titanate ($\text{PbTi}_3$)
- Lithium niobate ($\text{LiNb}_3$)
- Lithium tanalate ($\text{LiTaO}_3$)
Lab Methods of growing Natural Crystals

Czochralski Method

- One attaches a crystal seed at the bottom of a vertical arm such that the seed is barely in contact with the surface of the “melt”

- As the arm is raised slowly, crystals begin to form under the tip of the seed. As the seed is pulled, more crystals form.

- The computer-controlled arm can vary the pull rate to produce the desired diameter

- As the material solidifies (crystallizes) it forms a large circular boule
Bridgman-Stockbarger Method

- Polycrystalline material is deposited inside a sealed ampoule (similar to a pipette)
- The material is heated up inside a ceramic tube which has a gradient temperature
- The heaters will melt the material and maintain it at a molten state. As the ampoule is lowered, crystals begin to grow at the conical tip. The ampoule is lowered at the rate of crystal formation.
- When performed correctly a boule of crystal is formed.
- Method creates some impurities
How to make Piezoelectric Ceramics

All ceramics are man-made and are forced to become piezoelectric through a process of polarization.

The process of “poling” exposes ceramic material to a high-intensity electric field which aligns the electric dipoles and causes the ceramic to become piezoelectric.

Unfortunately, the process tends to reverse itself over time until it exponentially reaches a steady state (loses some of its piezoelectricity). Also, exposure to high temperatures, high levels of static charge and electric fields approaching its poling voltage, can cause ceramics to lose their piezoelectric properties prematurely.
Potassium Sodium Tartrate
(Rochelle Salt)

- First produced in 1675 by Pierre Seignette, a pharmacist from France.
- It was proven to have piezoelectric properties in 1880 by Pierre Curie and Jacques Curie.
- Was first used in microphones, speakers, gramophones during WWII.
- Use of Rochelle Salt stopped because it is soluble in water, and the crystals degraded over time.
- Medicinally used as a laxative.
- Used in the process of silvering mirrors.
Ingredients for Rochelle Salt

- Sodium Carbonate ($\text{Na}_2\text{CO}_3$, Soda Ash). Soda Ash can be found in Art stores.
- Potassium Bitartrate ($\text{KHC}_4\text{H}_4\text{O}_6$, Cream of tartar). Cream of tartar can be found in the spice sections in grocery stores.
- 250 mL water ($\text{H}_2\text{O}$).
Trials

The first solution we mixed was not successful, and may have been because we bought a substitute for Cream of tartar, or mixed the solution too fast for the reaction to react.

We spent two hours mixing this batch, and we only ended up with a useless slush.

The second solution we mixed, we purchased the more expensive Cream of Tartar, and spent over 4 hours mixing the solution.

After one night, several crystals formed and a few were removed to use as seed crystals. More crystals formed for a week, but all very small and untestable.

After several seed crystals were chosen, the rest were to be used in a supersaturated solution for crystal growth.
Seed Crystal Vs. Grown Crystal
Testing Apparatus design

Wave Generator
Testing
Resonance
Failed LED Test
Future Application: Piezoelectricity from California Roadways

Assemblyman Mike Gatto has proposed using piezoelectric technology on highways as a power-generating source (Bill AB 306).

Technology would create as much as 44 megawatts of electricity a year, for a single lane, 1 km long strip of road. This is enough to power 30,800 homes for a year.

Project would consist of placing cheap piezoelectric sensors underneath roads. Vibrations from cars would be converted into electricity, which could easily power signs and lights.

A similar system is already in use in Israel and Italy.
A Special Thanks to

- MESA (AKA Darci Rosales) for providing Legos
- Physics Department for the Oscilloscope, function Generator, and LEDs
- Professor Younes Ataiiyan for providing copper foil and help on our test.
- Luis for gracing us with his swag.
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