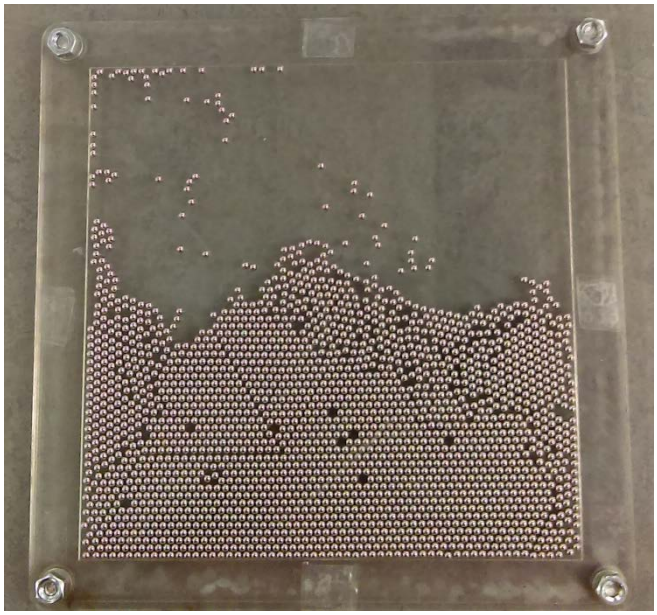
BB Box Crystal Simulator

Overview:



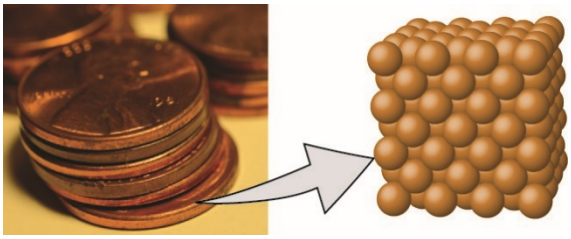
Build a demo with thousands of ball bearings trapped between two pieces of acrylic plastic.

Essential Question.

Can we model how atoms pack closely to form crystals?

Background:

Self-assembly is the idea that particles can organize themselves into complex structures with a high amount of order. Closely packed balls of the same size will eventually sort themselves into tightly packed rows that look like the atoms arranged in crystals. At the molecular level crystals form when atoms align themselves in the position with the lowest energy in response to layers of crystals already in place. It's very hard to see crystals form at the nano-scale. You can see the macro effect of ordered solids in large crystals that mimic the geometry of their smallest. This model is most analogous to the structure of a metal formed of identical atoms.



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Research Connection:

Our researchers create nano-crystals which have interesting properties at the nanometer scale. Defects in the crystals can add to or detract from the useful properties of a nanocrystal.

NGSS Standards:

Standard Number	Standard text
MS-PS1-1	Develop models to describe the atomic composition of simple molecules and extended structures.

Materials:

- 18"x 24" x 1/8" acrylic sheet
- 8 x ¼ -20 bolts and nuts.
- 8 or 16 washers
- 2000 1/8" steel ball bearings or BBs
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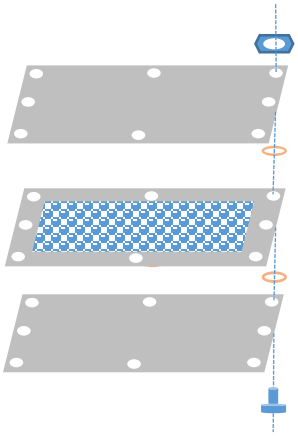
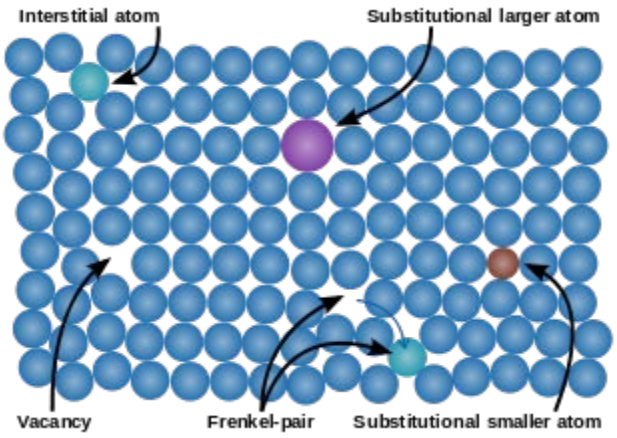
Procedure:

1. Load the BBBox2.ai file into the laser cutter control program. The program may open the file as a pdf, and then it can be "printed" to the laser cutter as a print device. Position the model on the cutting platform where you wish.
2. Place a piece of 1/8 acrylic plastic on the cutting platform in the same position.
3. Carefully check the registry of the plastic to be sure that each corner matches the position of the positioning laser. Instructions for aligning the laser will vary depending on the cutter.
4. Cut the piece. After cutting clean the pieces, pop out the center piece and each hole.
5. Place 8 bolts into the holes on the back panel so they face up with the panel sitting flat on table resting on the bolt heads.
6. Place a washer on teach exposed bolt.
7. Slide the inner edge guide on the bolts.
8. Place another washer on each bolt. These two washers should provide enough space so that the BBs roll freely when the top is in place, but no so much space that the BBs can stack outside of single plane. Place the top face on and bolt in place. Confirm that the BBs roll freely but do not stack up. Adjust the number of washers accordingly.
9. Tighten the nuts.



Demonstration

1. Tilt to show that BBs will attempt to pack perfectly into rows but inevitably there will be flaws. Look for the presence of vacancy defects, crystals, grain boundaries, dislocation defects.
2. Shake the frame to attempt to get a 100% close packed structure.
3. Use a weak magnet to show that a group of BBs form a hexagonal crystal structure. (Don't use too powerful a magnet or you will can magnetize the balls and they will behave differently and form long strands rather than random and then ordered packing)
4. Tilt the demo to level and gently tap it to show an analogy for sublimation, melting, or evaporation.
5. Rub a piece of felt on surface as the box is held level to transfer charge to the BBs. Notice that the charged particles will repel each other and begin to form an evenly spaced field.



https://commons.wikimedia.org/wiki/File:Point_defects_in_crystal_structures.svg

Extensions:

Try introducing balls of different sizes to illustration substitution of smaller atoms.

Resources:

- Lasercut design
- https://www.cei.washington.edu/educationspace/BBBOX2.ai
- http://www.atomsinmotion.com/educators

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Sources:

- Ball bearings 1000 $10.27

  https://www.amazon.com/gp/product/B007B2AID4/ref=ppx_yo_dt_b_asin_title_o01__o00_s01?ie=UTF8&psc=1