Engineering/Art Synergy: Photopolymerization

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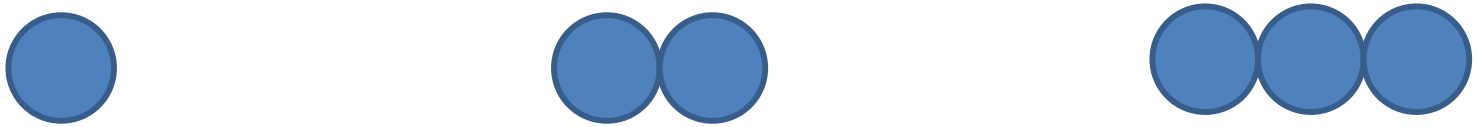
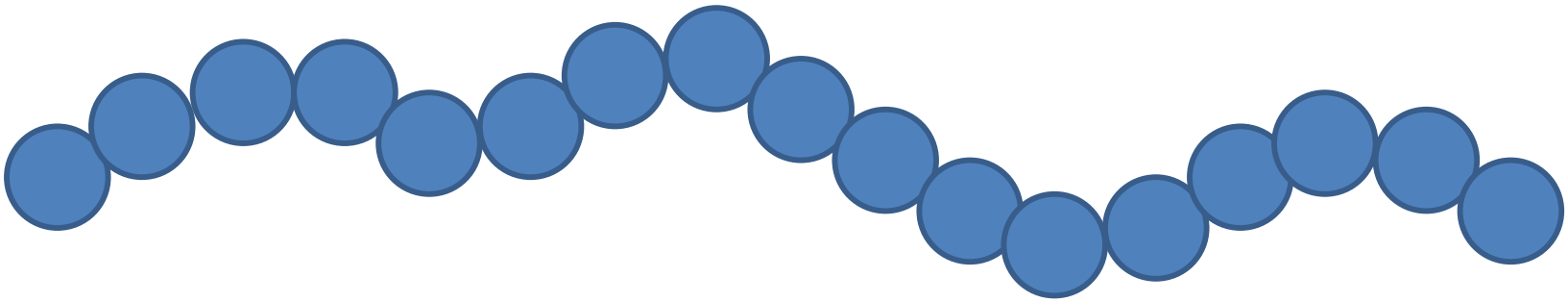
What is a Polymer?

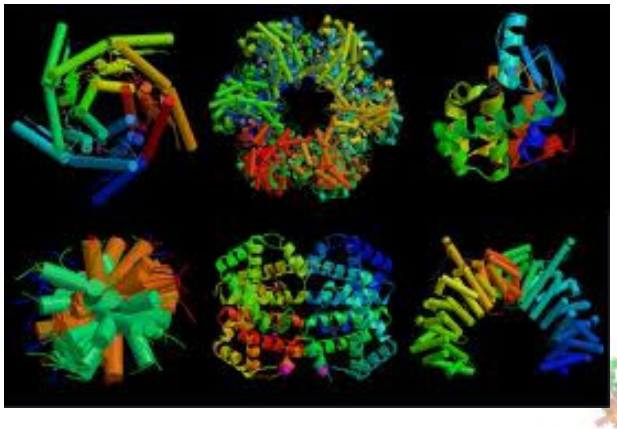


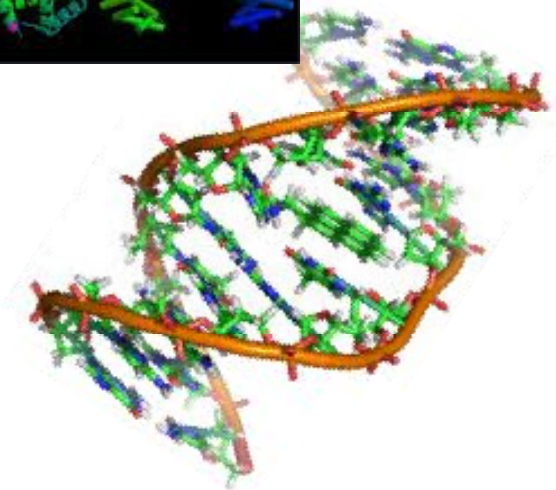
Monomer Dimer Trimer

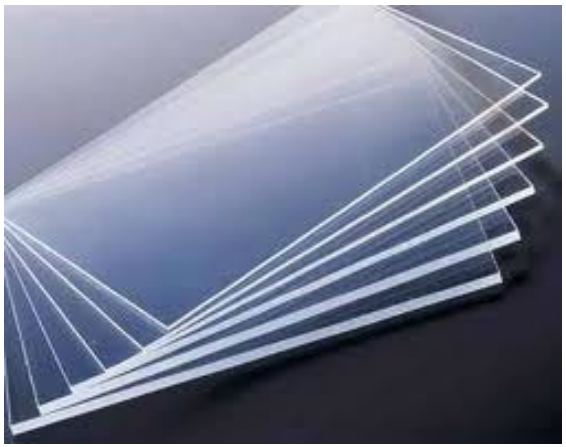


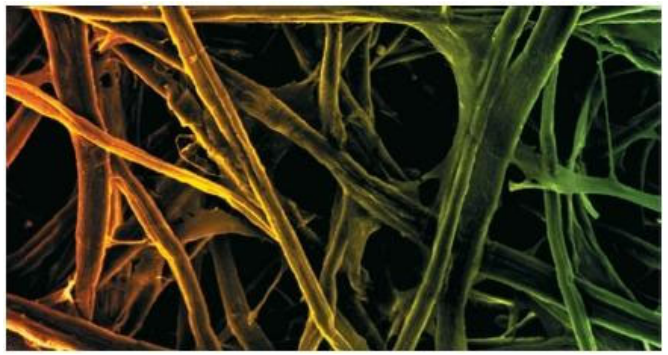
Polymer

Polymers





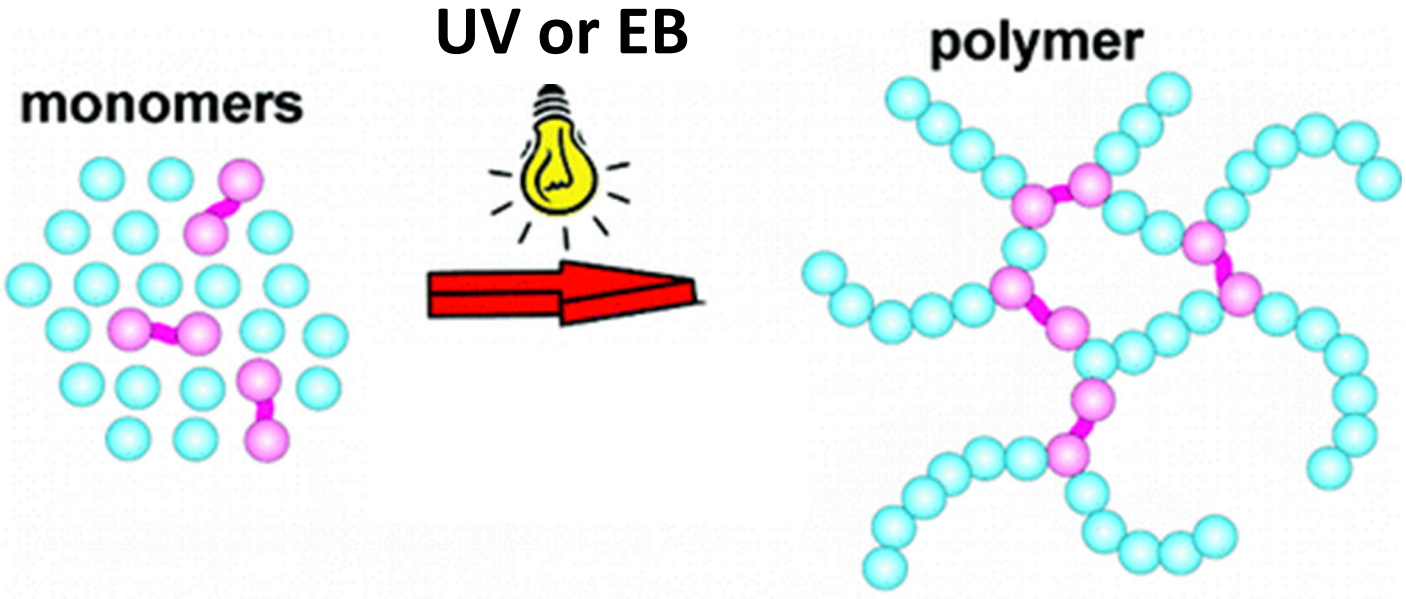




What is photopolymerization?

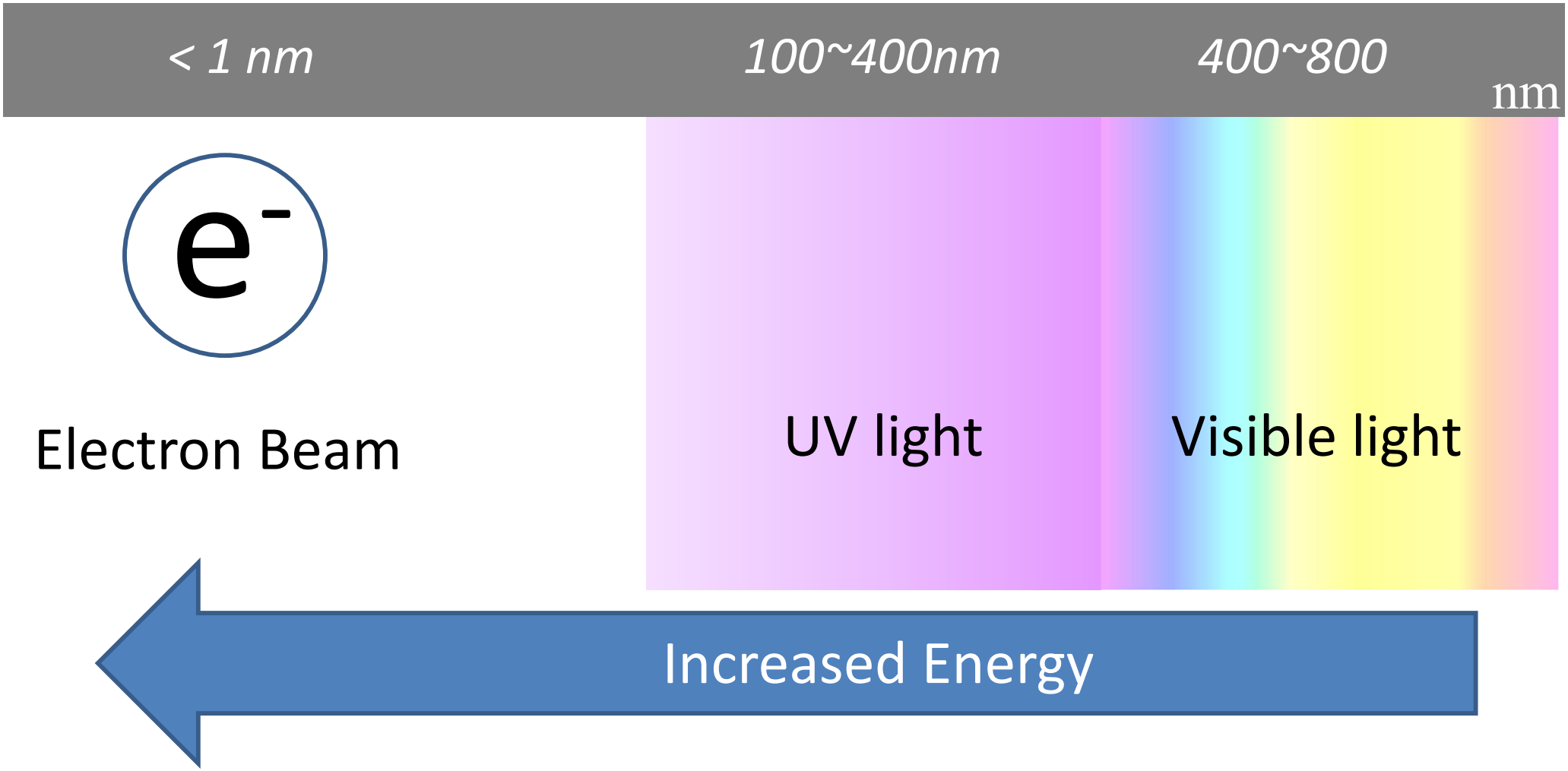
- Light energy, instead of heat, is used to form macromolecules

Photopolymerization



Liquid **Solid**

UV/EB radiation



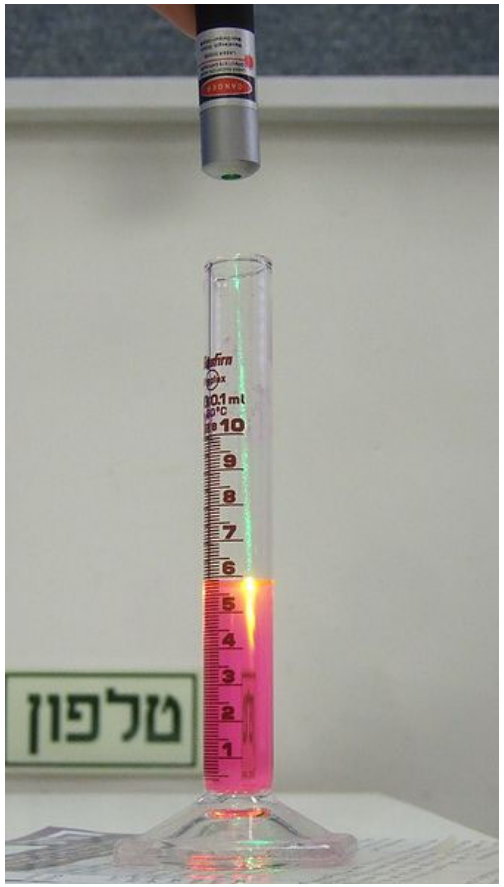
Advantages of Photopolymerization

- Increased productivity
  - High speed reactions, high production rates
  - Control of initiation
    - Spatial
    - Temporal
- Environmental Benefits
  - Lower energy costs
  - Room temperature reactions
  - Low or no VOC (solventless formulations)

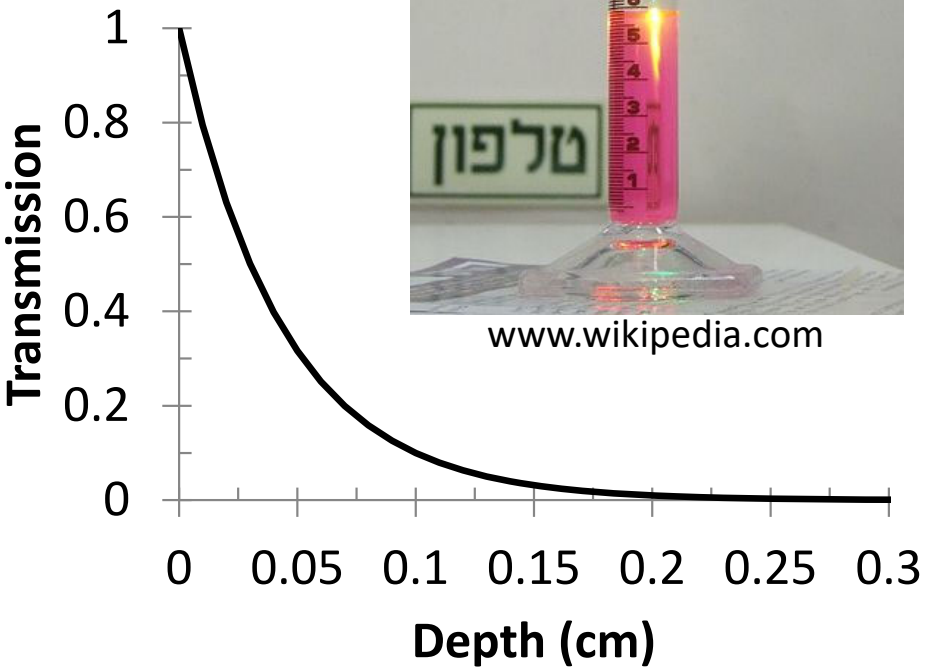
Disadvantages of Photopolymerization

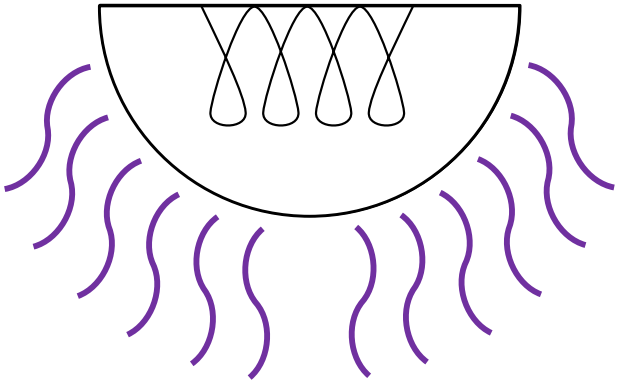
- Polymerization induced shrinkage, high speed reactions, high production rates (can be as high as 25%)
  - e.g. Coatings
    - Buckling, wrinkling
  - e.g. Dental fillings
    - Cracking of tooth or filling, microleakage
- O_2 inhibition
  - Sticky surface
  - N_2 purge might be required
- Difficult to cure thick samples
  - Optical path limitation

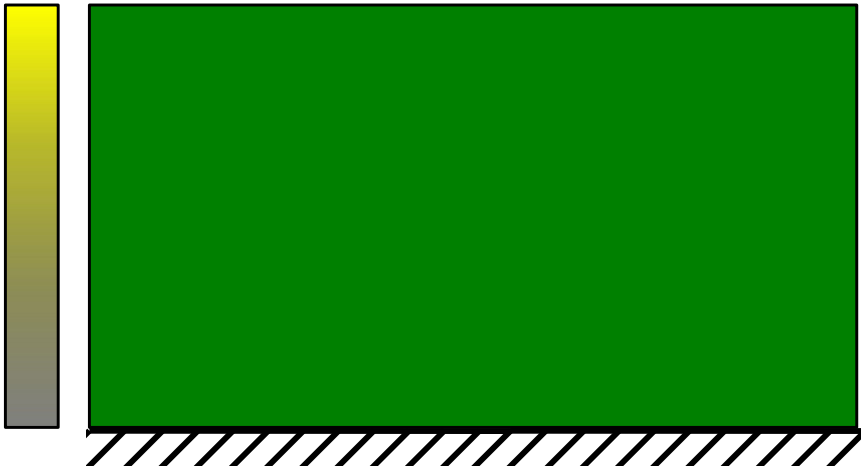
Why thickness is limited….



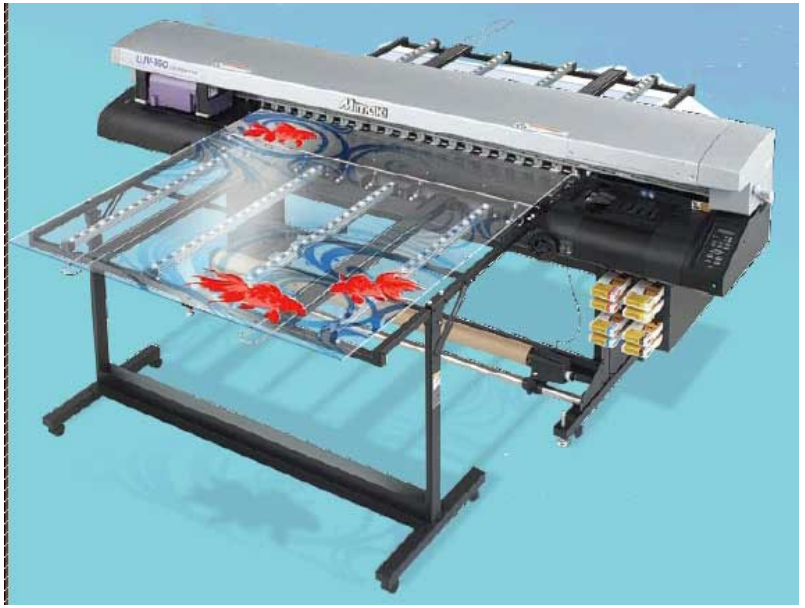
www.wikipedia.com



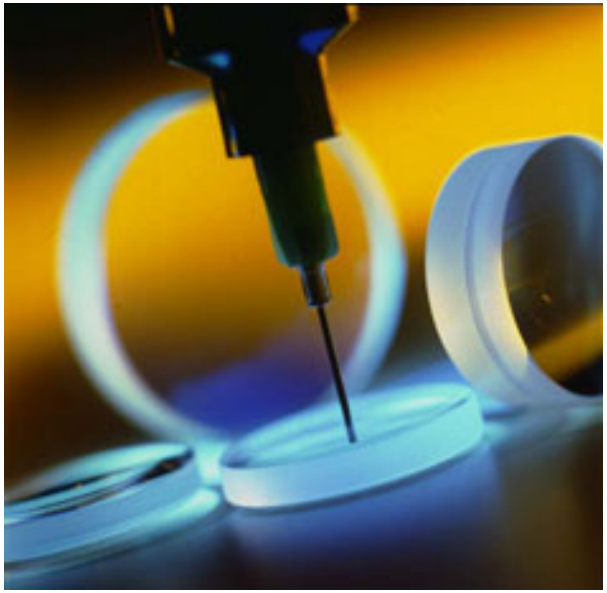


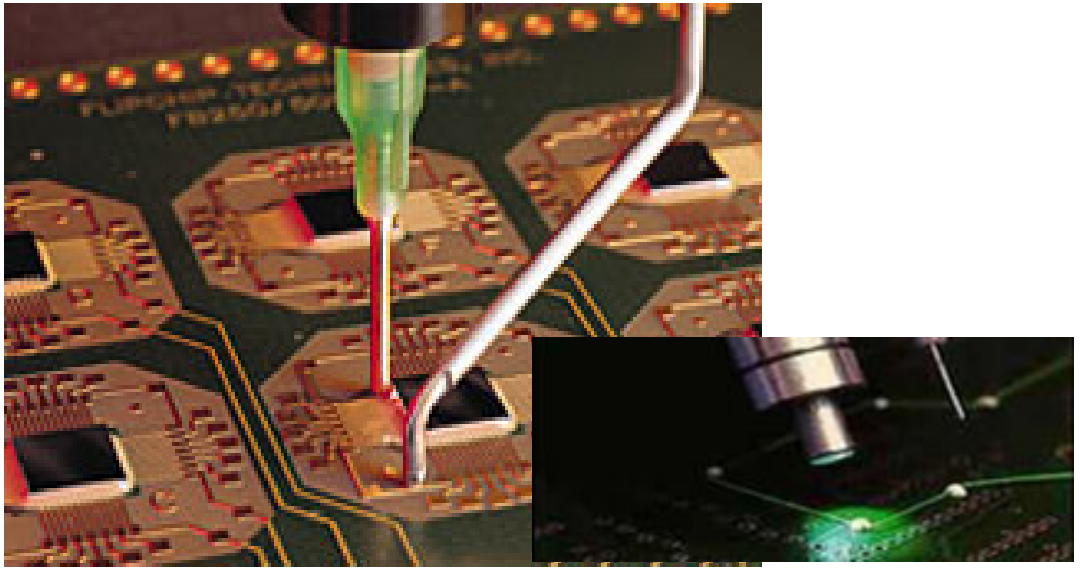


Application: Printing

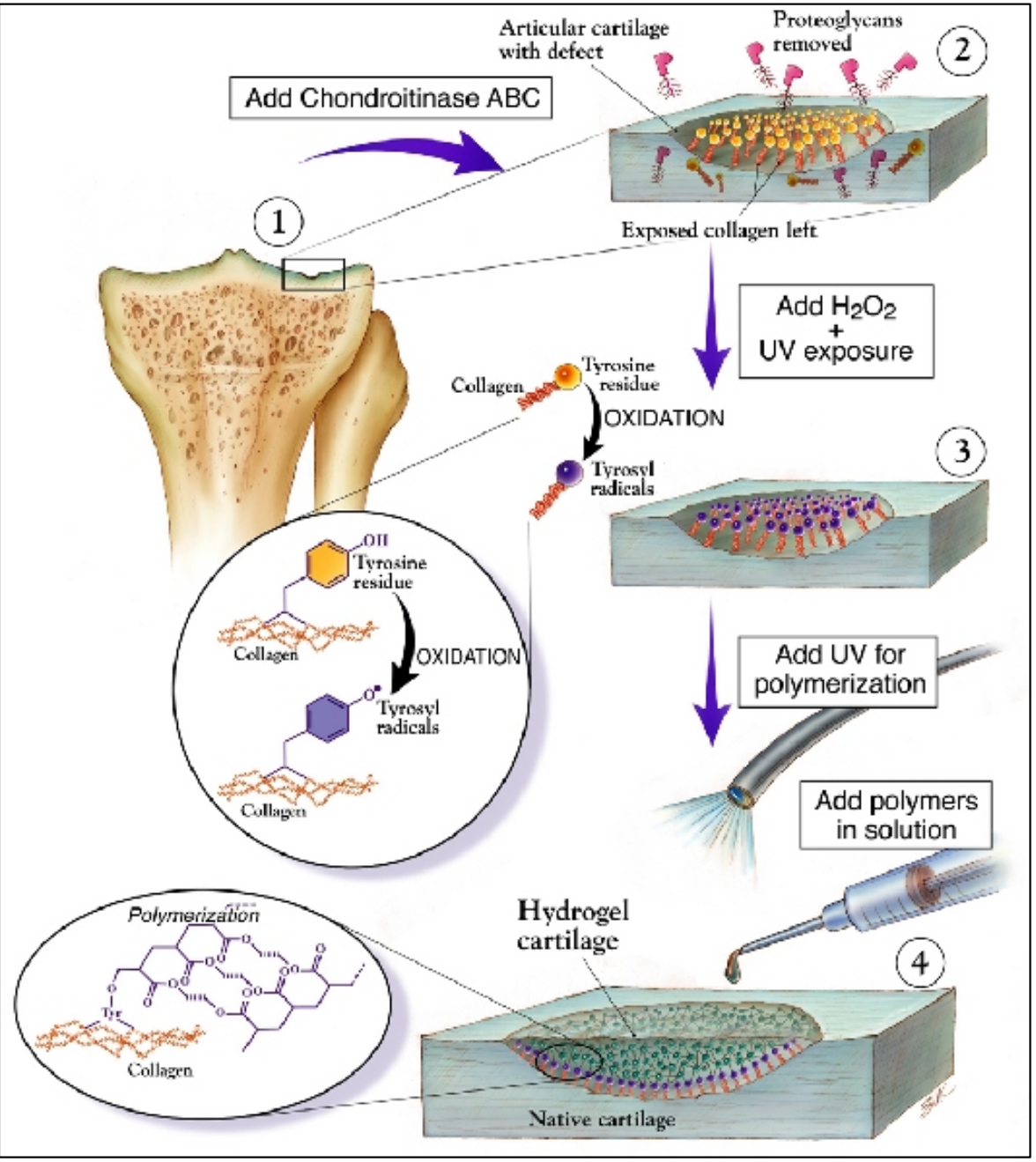


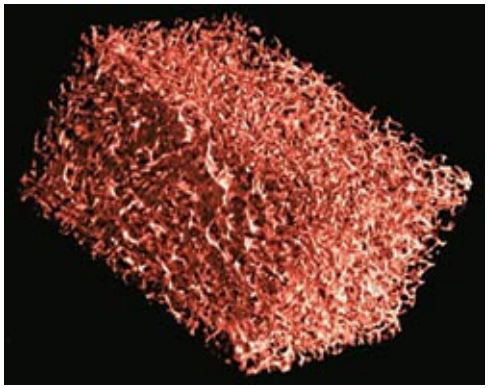
Application: Coatings & Adhesives

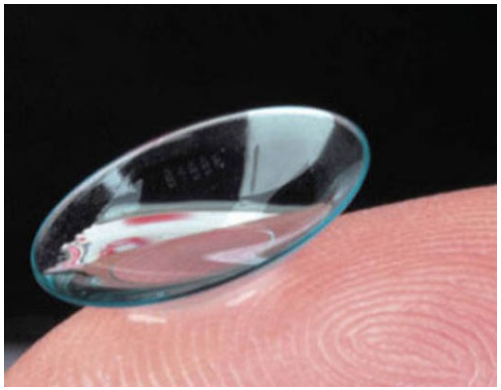


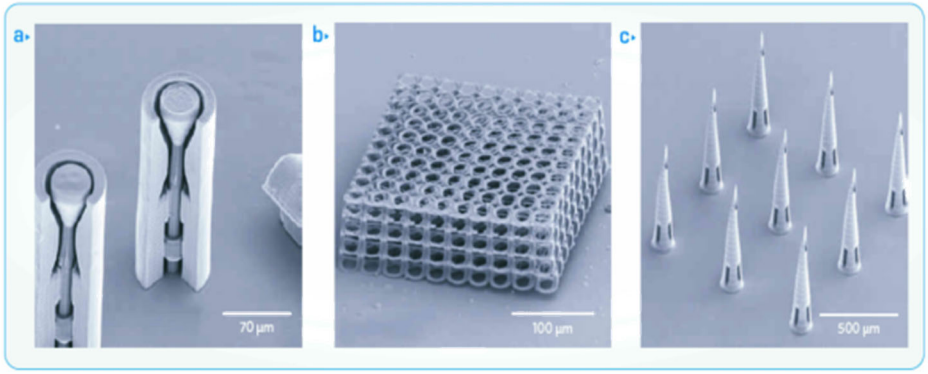


Application: Biomaterials

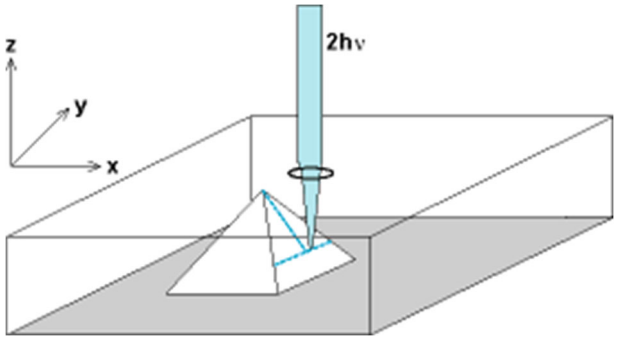


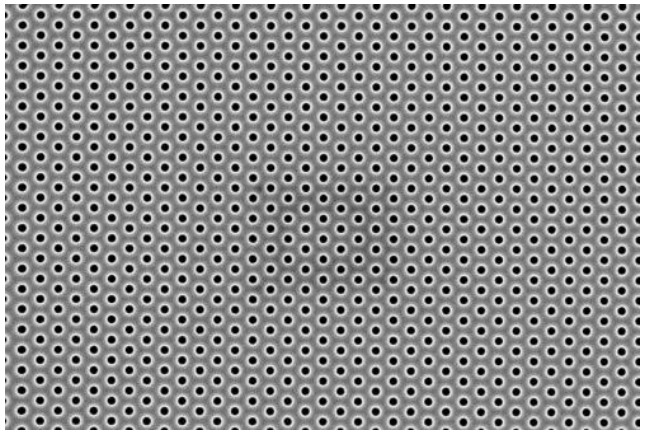


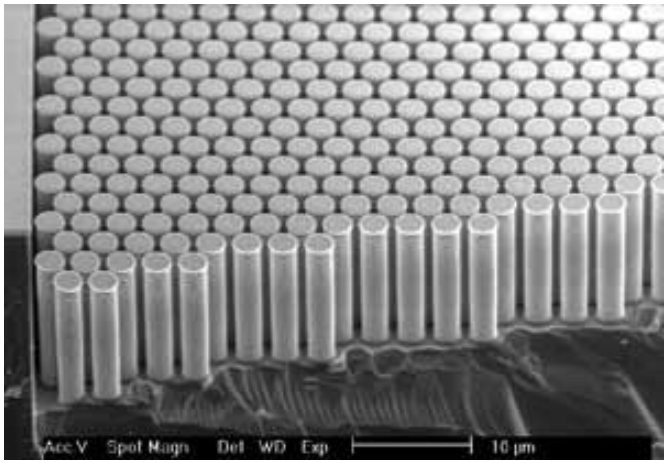


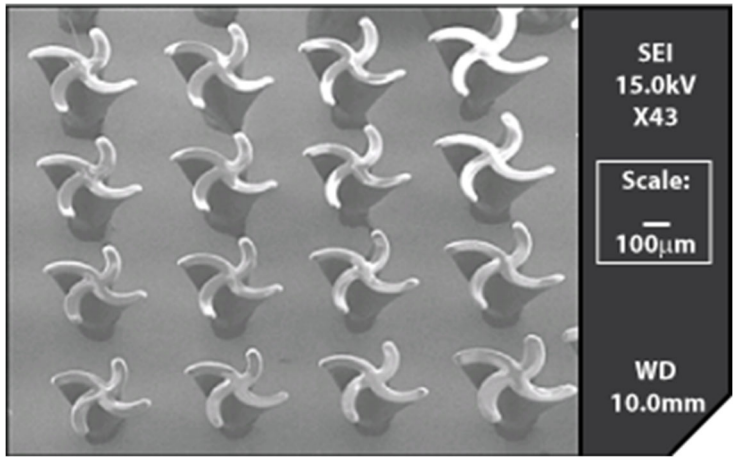


Application: Lithography (2D, 3D)









Summary

Economics of UV/EB | Sustainable UV/EB | Everyone Wins

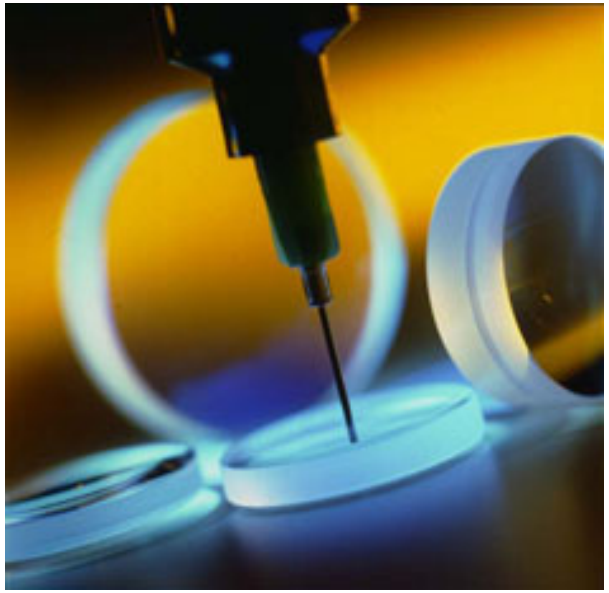
Although the definition can be subjective, sustainable manufacturing processes have the following characteristics:

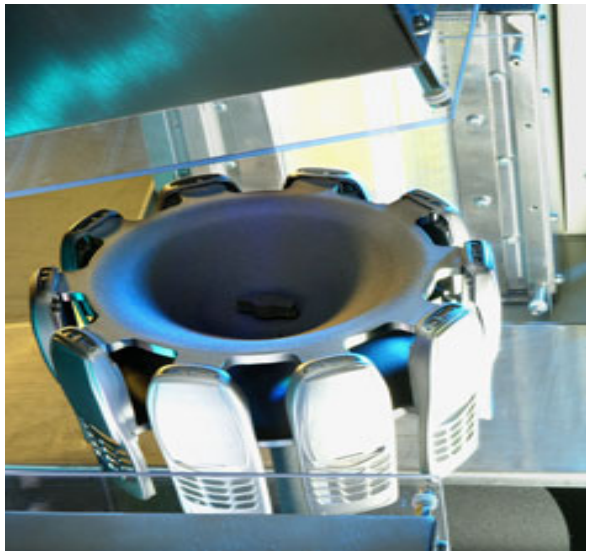
1. Improve efficiency
2. Reduce waste
3. Conserve natural resources
4. Save energy
5. Avoid toxic or other emissions
6. Contribute to a safe and healthy working environment
7. Use renewable energy and resources
8. Use products made from salvaged, remanufactured or recycled material

End

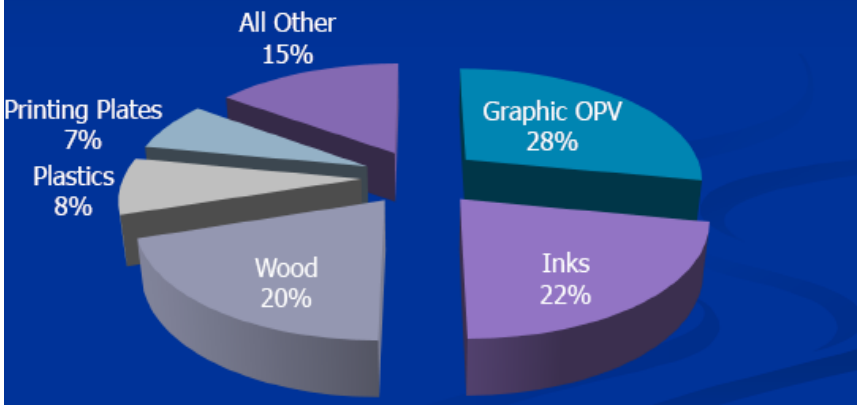
Water born coating vs. photopolymer coating

Applications





UV/EB Formulated Product Market North America ~ $1 Billion



By % of market, metric tons

Estimates of Average Annual Growth over the next few years for UV/EB:

3D Inkjet/Stereolithography	21%
Field Applied UV	18%
Photovoltaics	16%
Structural Adhesives	15%
Inkjet	15%
Sprayable Coatings for 3D	15%
Plastic Coatings	14%
Aerospace	12%
Food Packaging	10%
Waterbased UV	10%

Motivations for using UV/EB

1. Increase Productivity (1)
2. Lower Energy Costs (5)
3. Improve Physical Properties (2)
4. Environmental Benefits (3)
5. Enabling Technology (4)

UV/EB Formulated Product Usage North America

(Metric Tons)