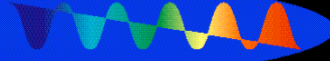




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ENGINEERING

*Photodigm*



Biophotonic Research  
(Edited for PHOTON PBL)  
Laser Array for Photodynamic Therapy

# Acknowledgements



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# Photodynamic therapy basics

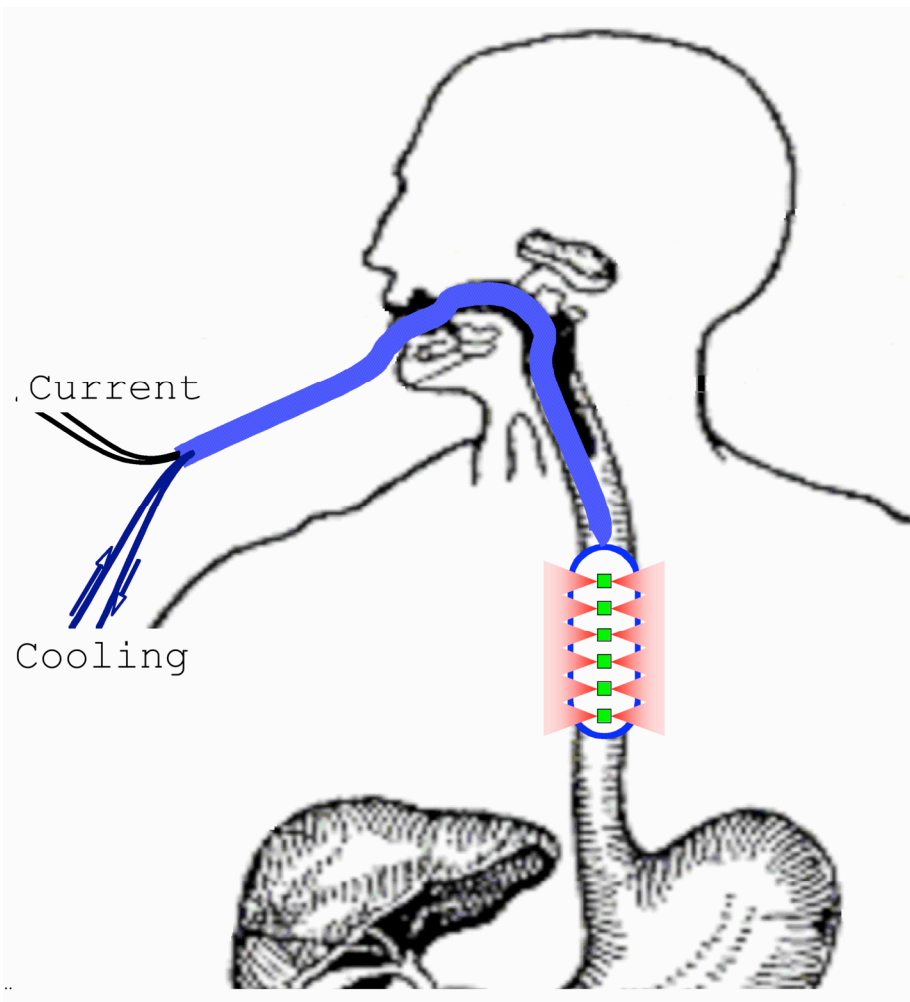
PDT is a treatment modality involving administration of a photosensitizing agent, accumulation of sensitizer agent in the target cells, followed by selective irradiation of the cells with red or near-IR light

- Is used for treatment of cancer, age-related macular degeneration, psoriasis, etc.
- Based on photosensitizing drug that can kill cells after activation by light of a specific wavelength
- Requires a light source and delivery system for activating the drug

## **Photodynamic therapy cancer treatment procedure:**

1. Inject a photosensitizing agent into the blood stream
2. Wait until agent accumulates in cancerous cells
3. Illuminate the cancer with laser light of a specific wavelength

# Direct illumination of the esophagus



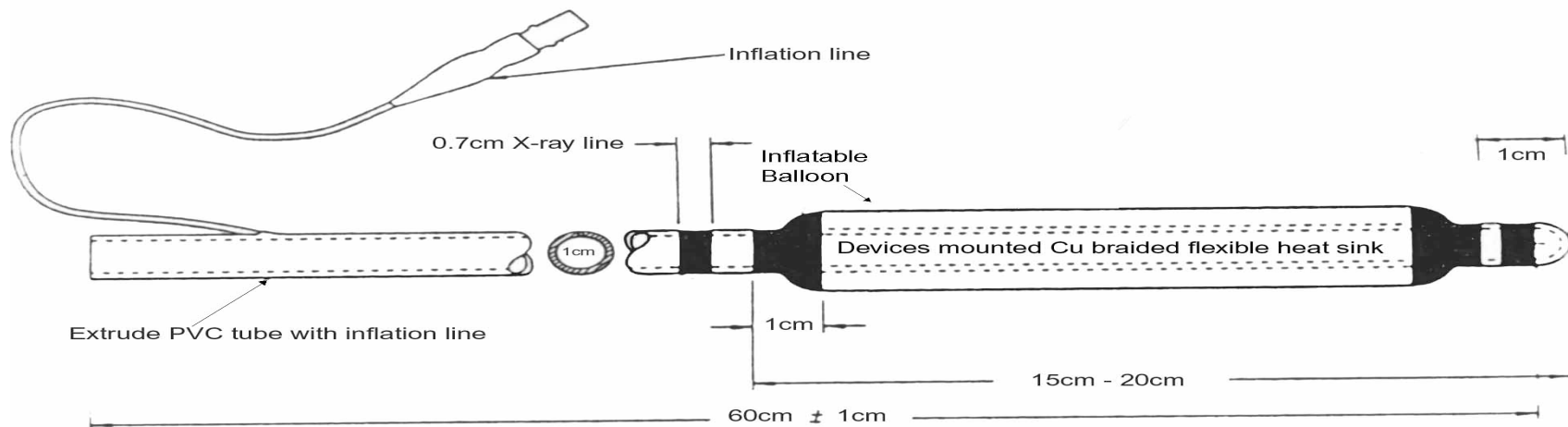
## Advantages:

- Portable, inexpensive
- No fiber optic coupling losses
- Laser section on/off capability
- Potentially smart systems with individual power control for each laser and oxygen detection capability

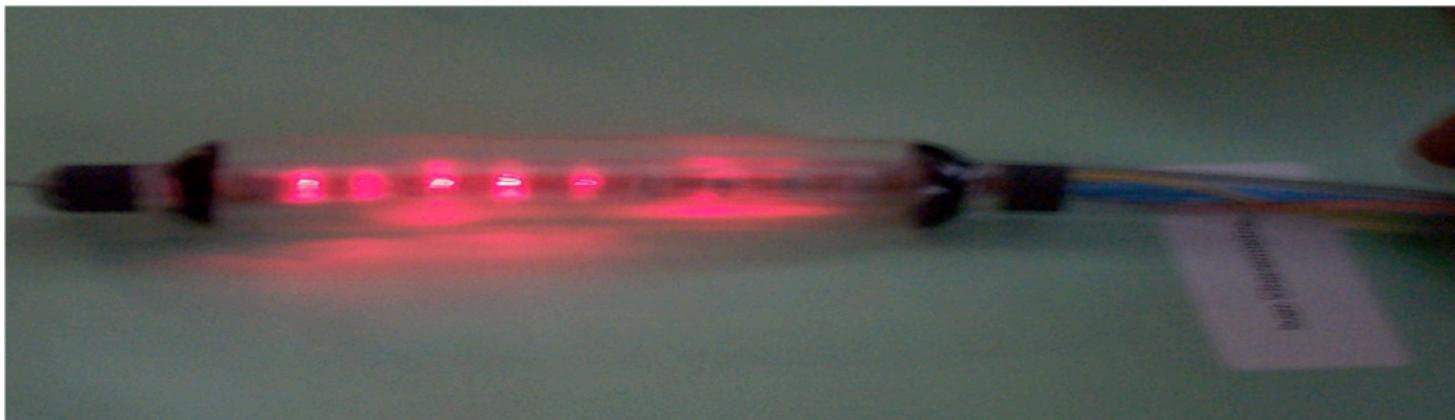
## Disadvantages:

- Bigger diameter than fiber
- Could be used for large cavity cancers.
- More sophisticated laser packaging

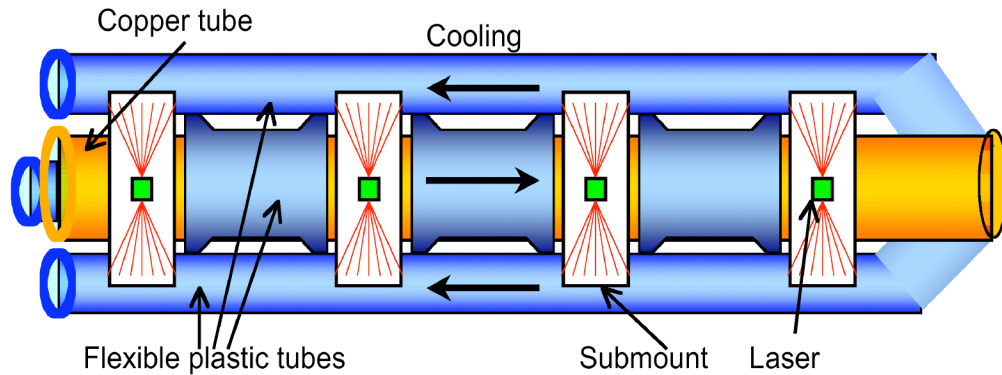
# Investigation of a balloon catheter



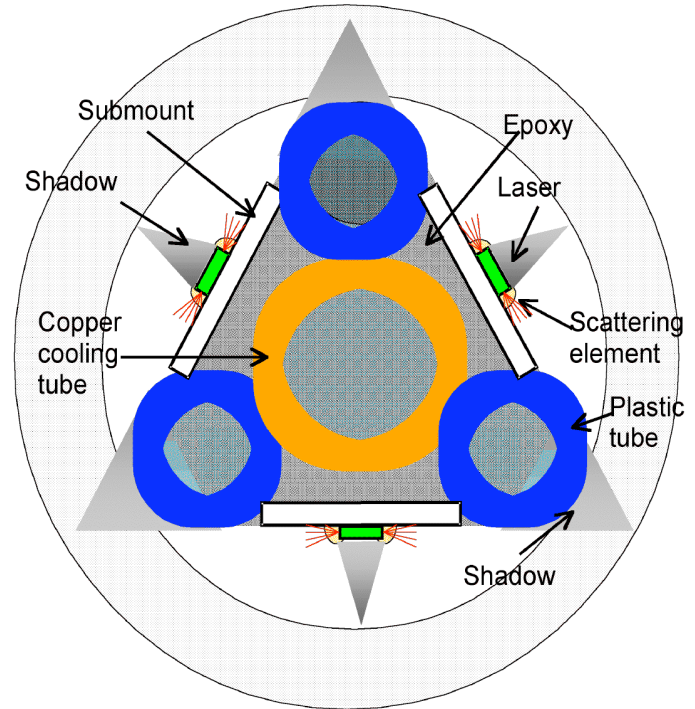
## Prototype for Barrett's Esophagus



# Laser insert design



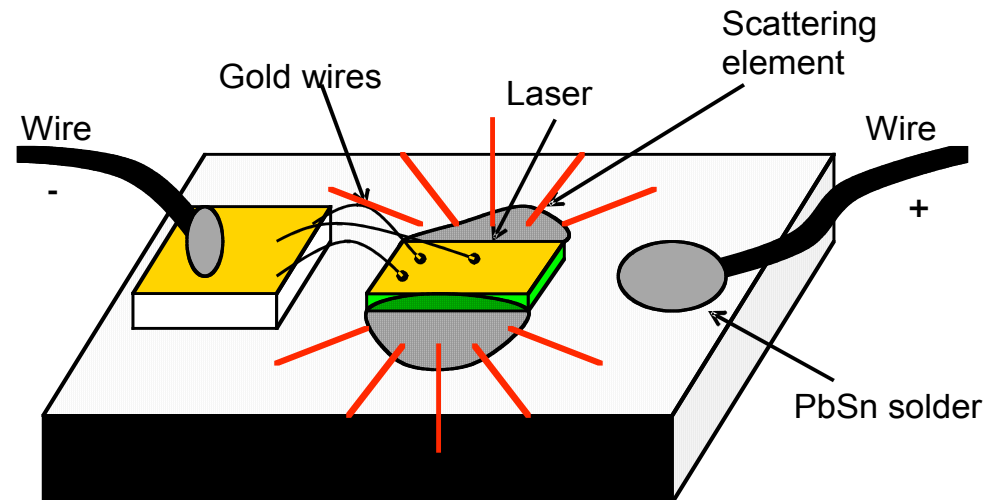
Side view



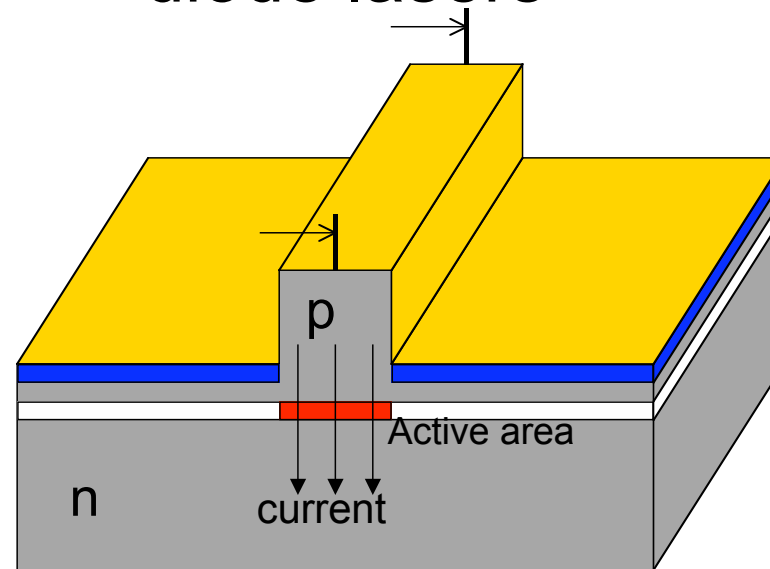
Cross-section

Main challenges:

- Uniform illumination
- High power laser operation
- Uniform cooling
- Small size
- Flexibility



# Laser epitaxial structure design: Semiconductor diode lasers



## Features:

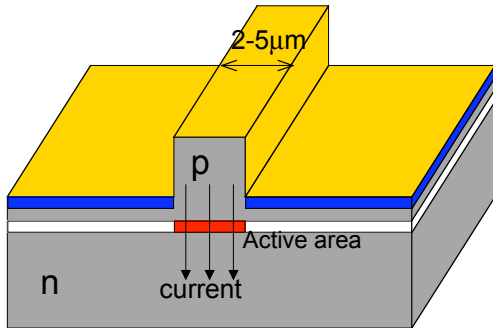
- Consists of multiple layers of different semiconductor alloys
- All layers are single crystal and lattice matched to each other
- Light amplification occurs in  $\sim 100\text{\AA}$  active layer

## The key requirements of the efficient operation:

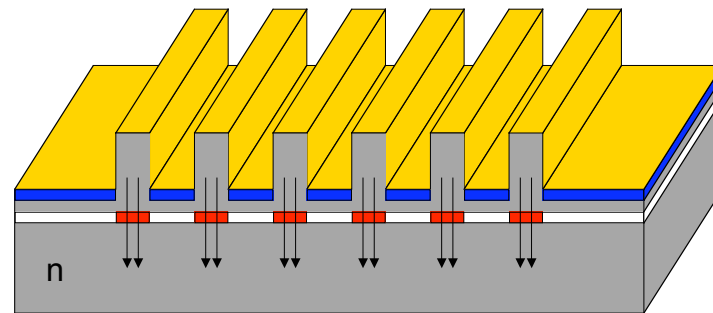
- Electron confinement to the active layer
- Photon confinement to the active layer

# Ridge waveguide arrays

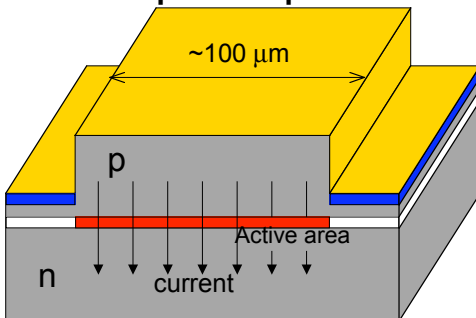
Ridge waveguide (RWG):  
Reliable, but low power



Ridge waveguide array:  
Reliable high power operation

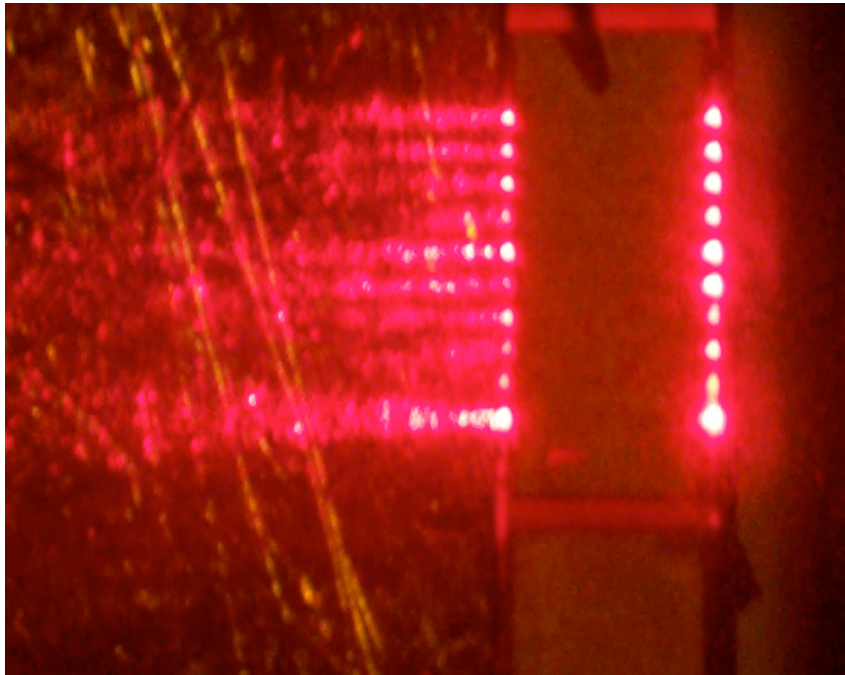


Broad area laser:  
High power, but susceptible to  
Catastrophic optical damage (COD)

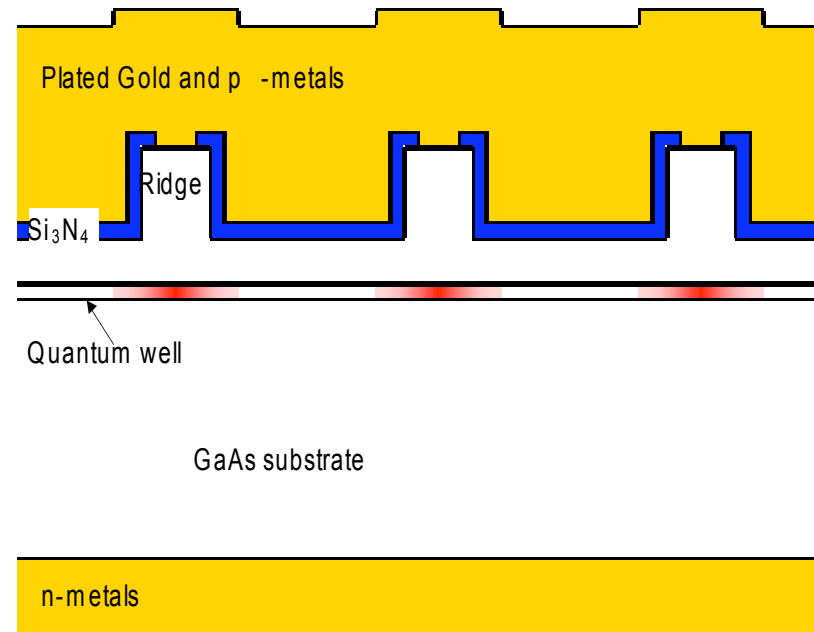




# High power laser array



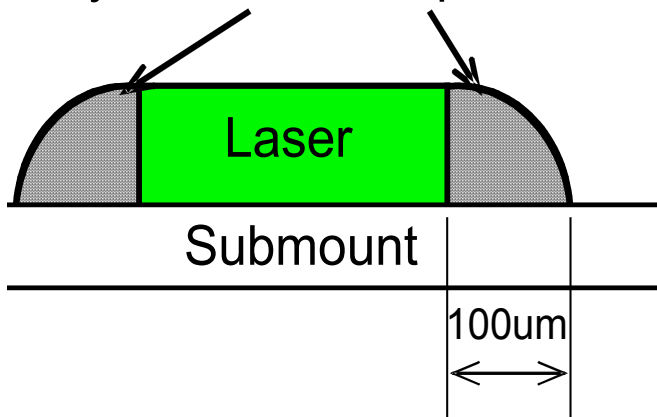
**Lasing array of 10 ridges**



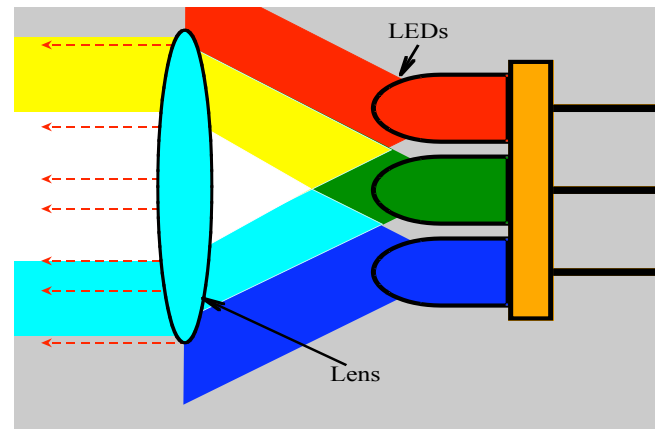
**Cross section of a laser array**

# Achieving uniform illumination: Light scattering element

Polymer with nanoparticles



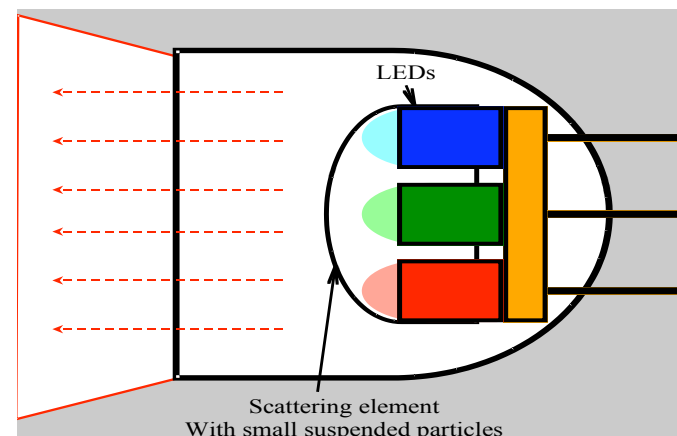
LED Automotive Headlights



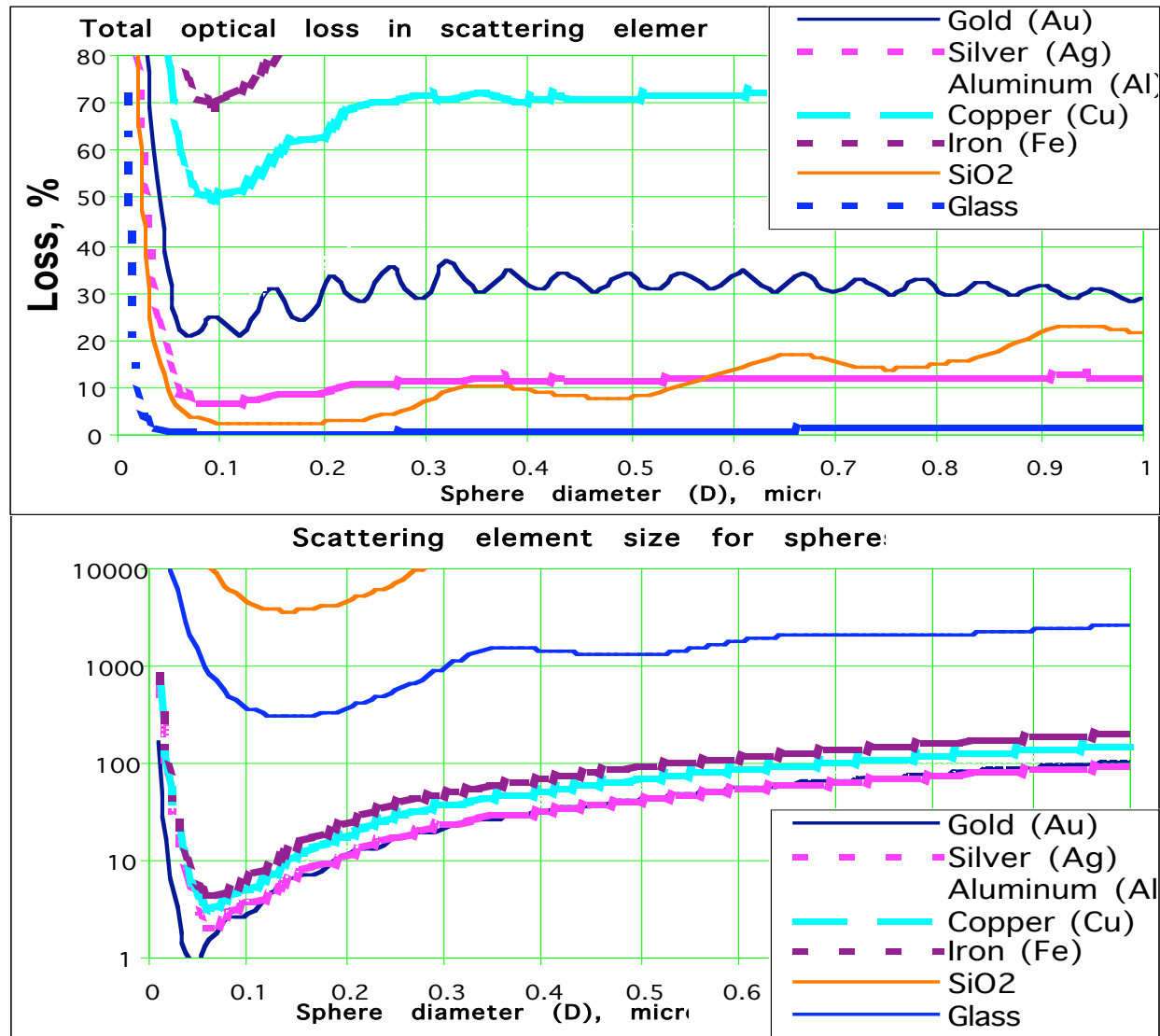
- Placed directly onto laser facets
- Uses small particles
- Particles are suspended in a transparent polymer to increase laser far field divergence and to achieve uniform illumination

**Patent Pending**

**Optimization goals**



# Scattering particle size optimization



# Scattering element with TiO<sub>2</sub> particles

Scattering element

