

Plasma Assisted Pulsed DC Magnetron Sputtering System for Optical Thin Film Coatings

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Abstract

Using plasma assisted pulsed DC magnetron sputtering technology, low loss, high performance optical coatings have been achieved. Multi-layer coating examples using Ta_2O_5 and SiO_2 materials are demonstrated. This technology is suitable for volume production.

Motivation

Offer a deposition tool for optical coating industry that combines the advantages of both

- E-beam evaporation (large area, fast rate)
- IBS deposition (stable process, superior film quality).

Approach

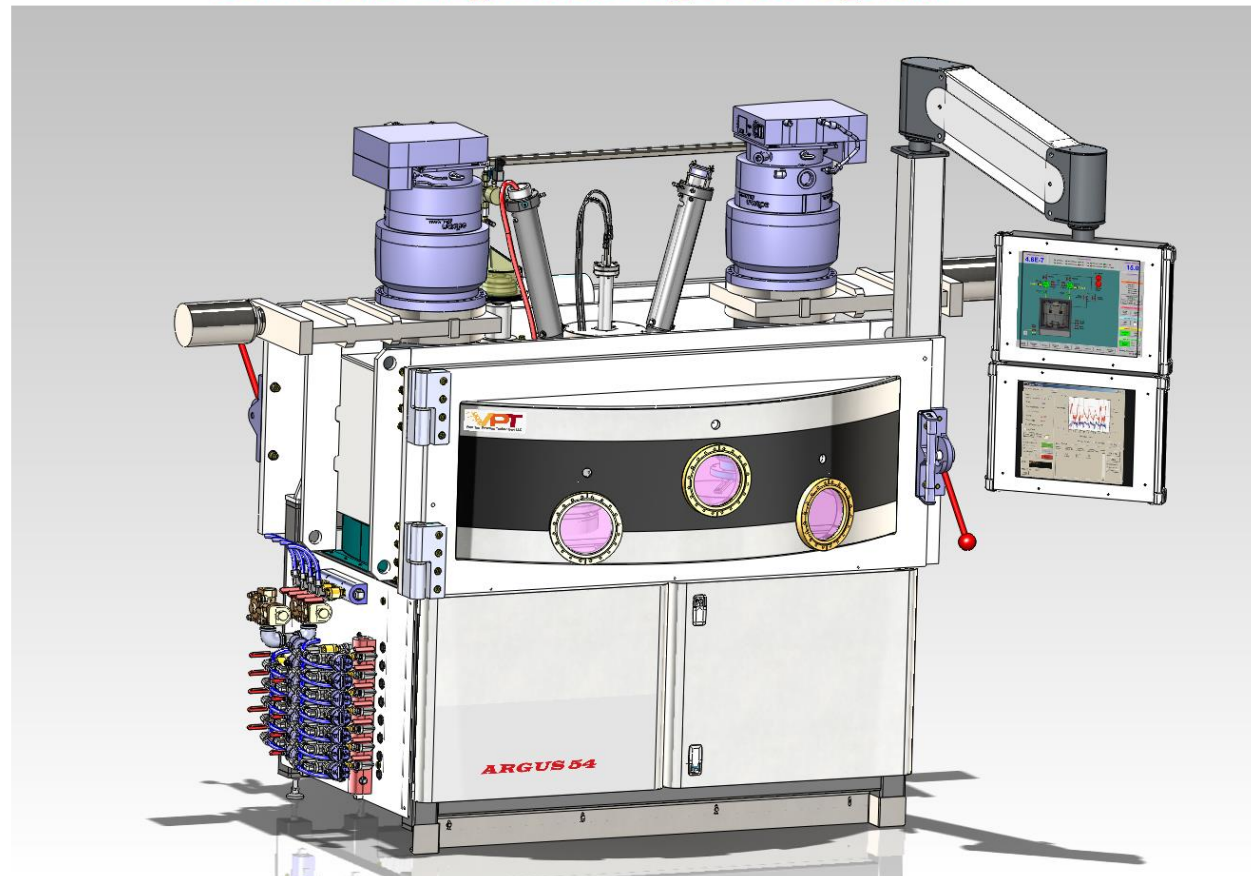
- Plasma Assisted Pulsed DC Magnetron Sputtering
- Real-time feedback control of O₂ flow to further improve process stability
- Film thickness controlled by time–power
- Planetary system with up to six 400mm planets

Experiments

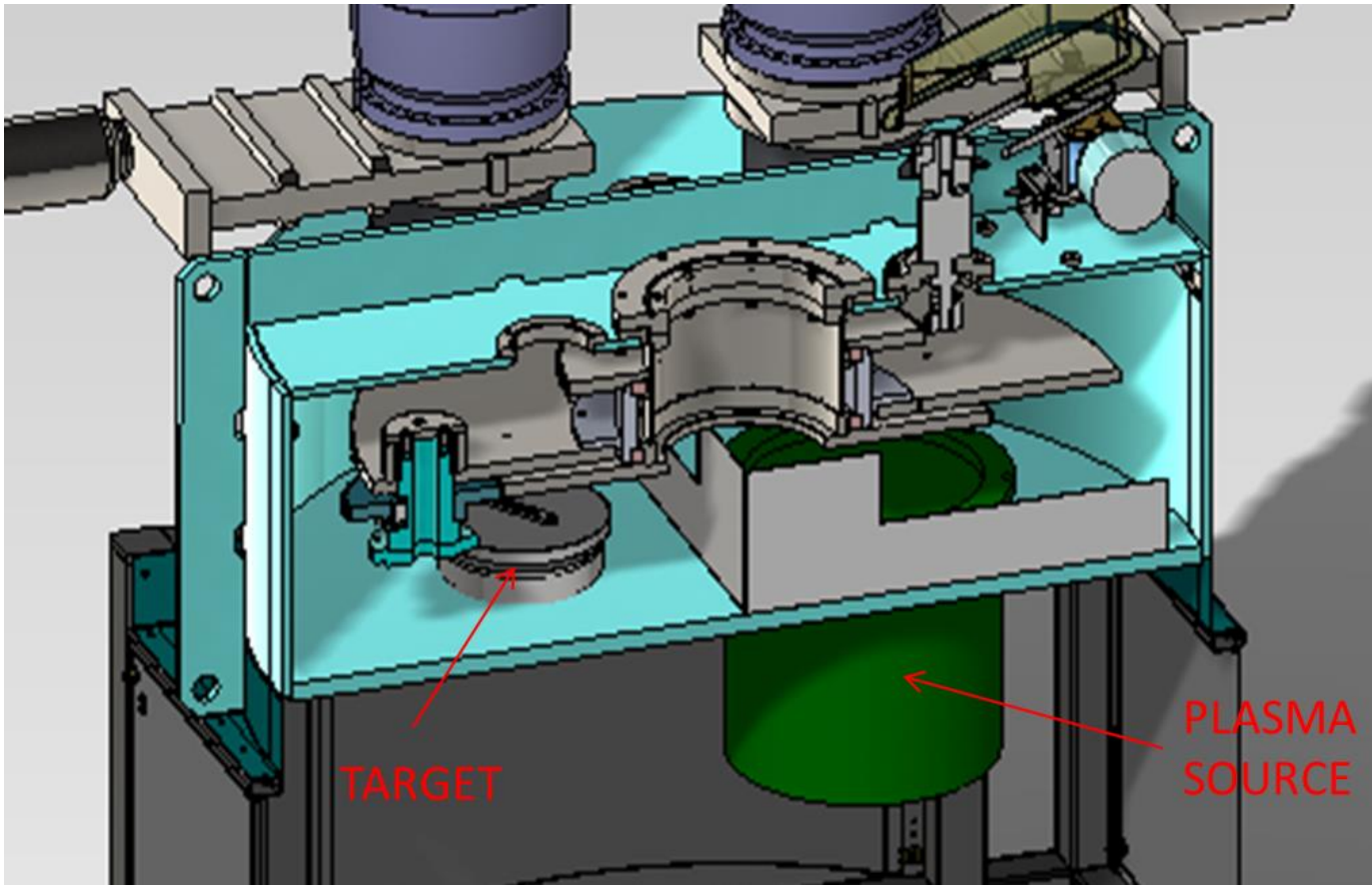
- Ta and Si targets were installed and efficiently sputtered to form Ta_2O_5 and SiO_2 thin films
- Characterized Ta_2O_5 and SiO_2 film properties:
 - n & k
 - Stress
 - Uniformity
- Coating examples

Optical Sputter Coater

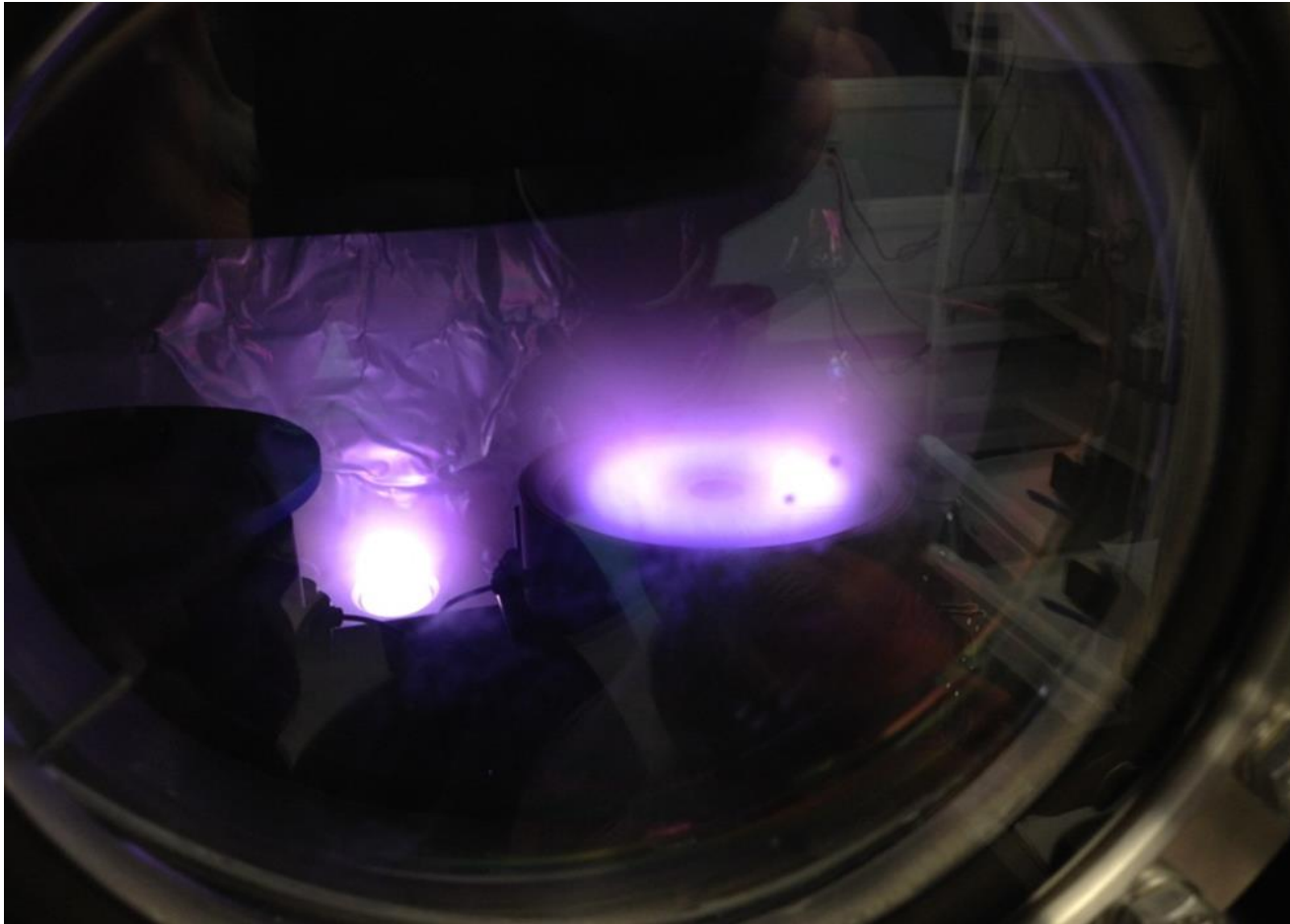
ARGUS - Sputtering For Optics



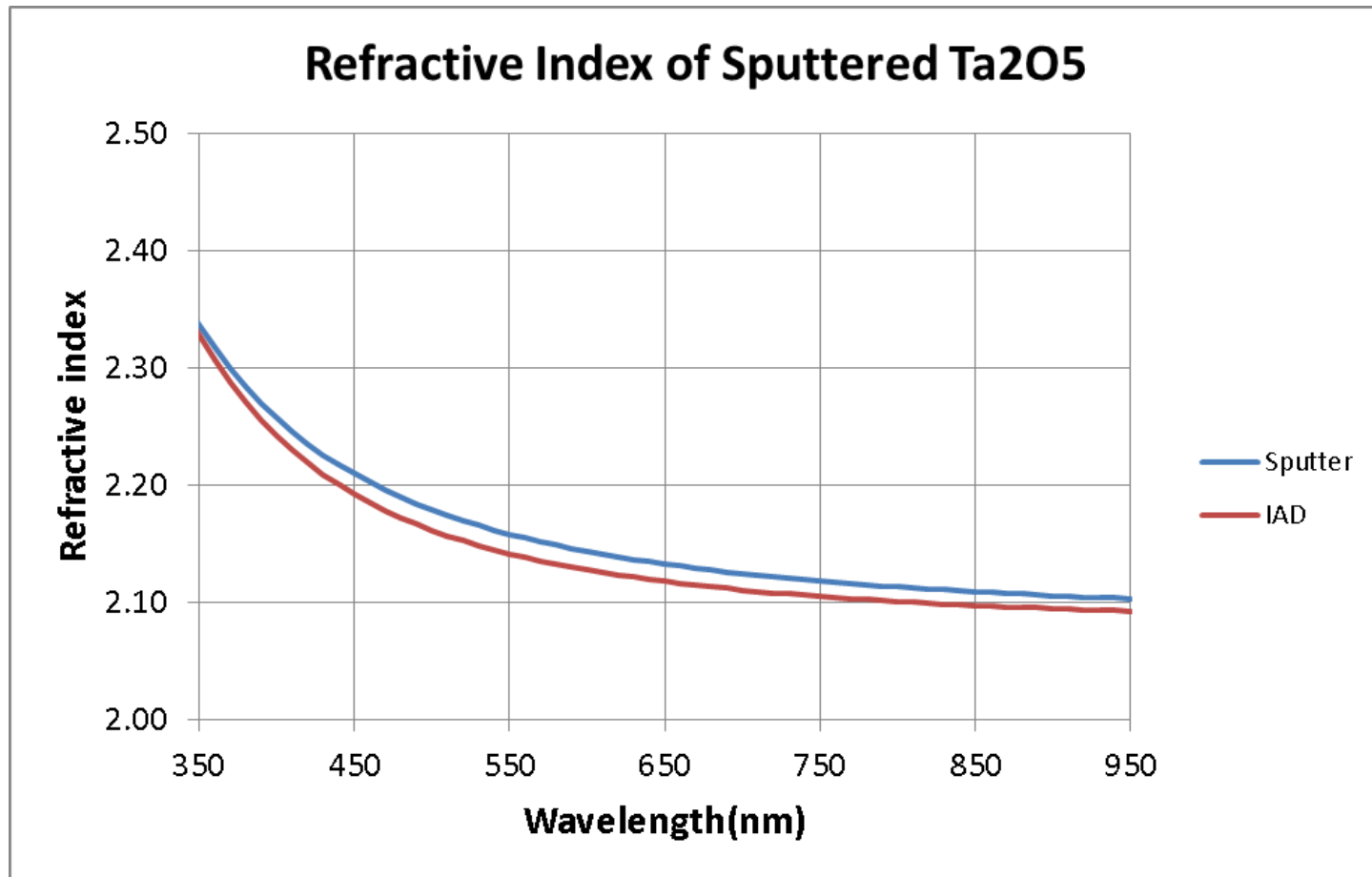
Optical Sputter Coater Overview



Optical Sputter Coater in Operation



Single layer Ta₂O₅, 5.0 Å/s



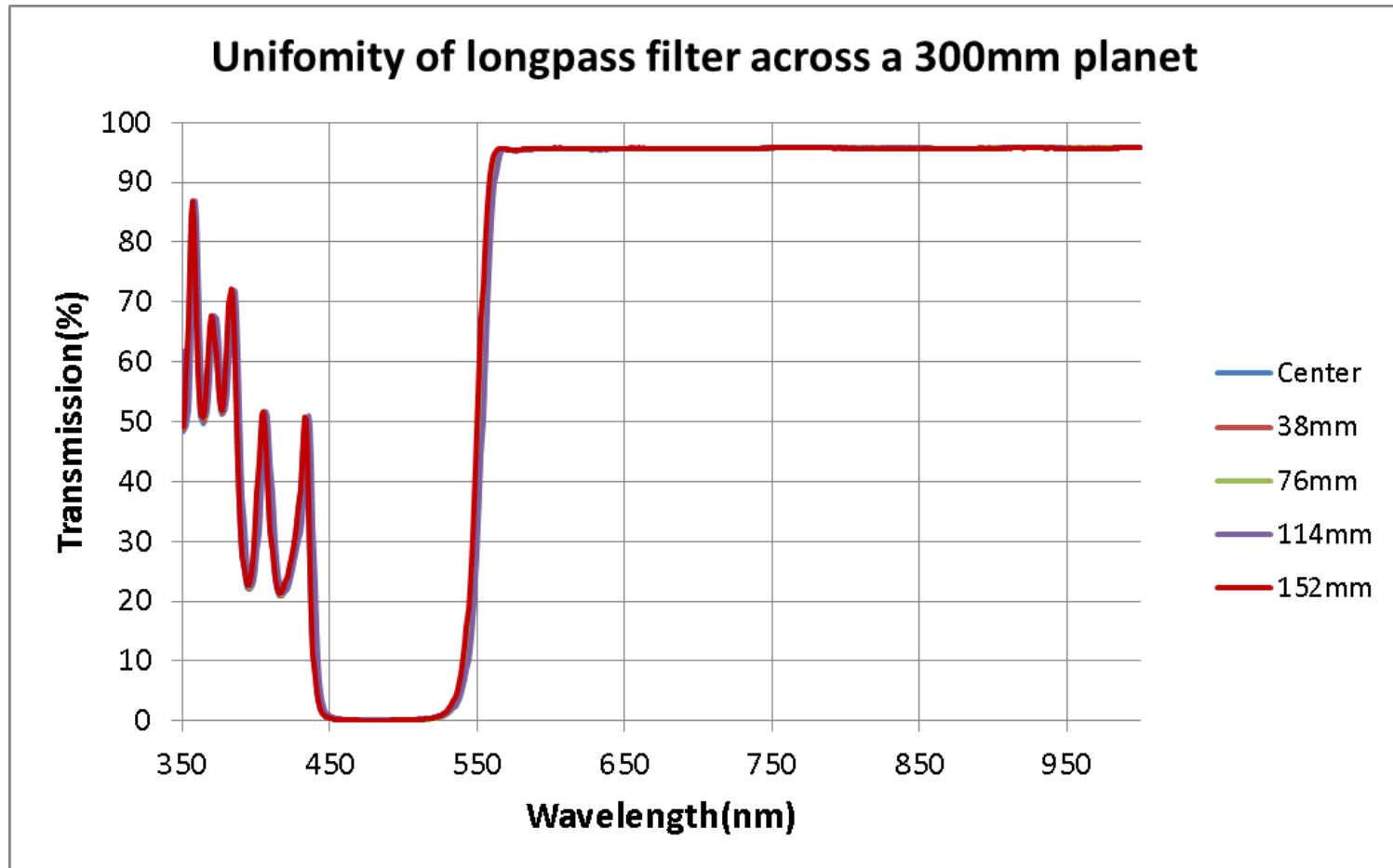
Single layer SiO₂, 6.0Å/s



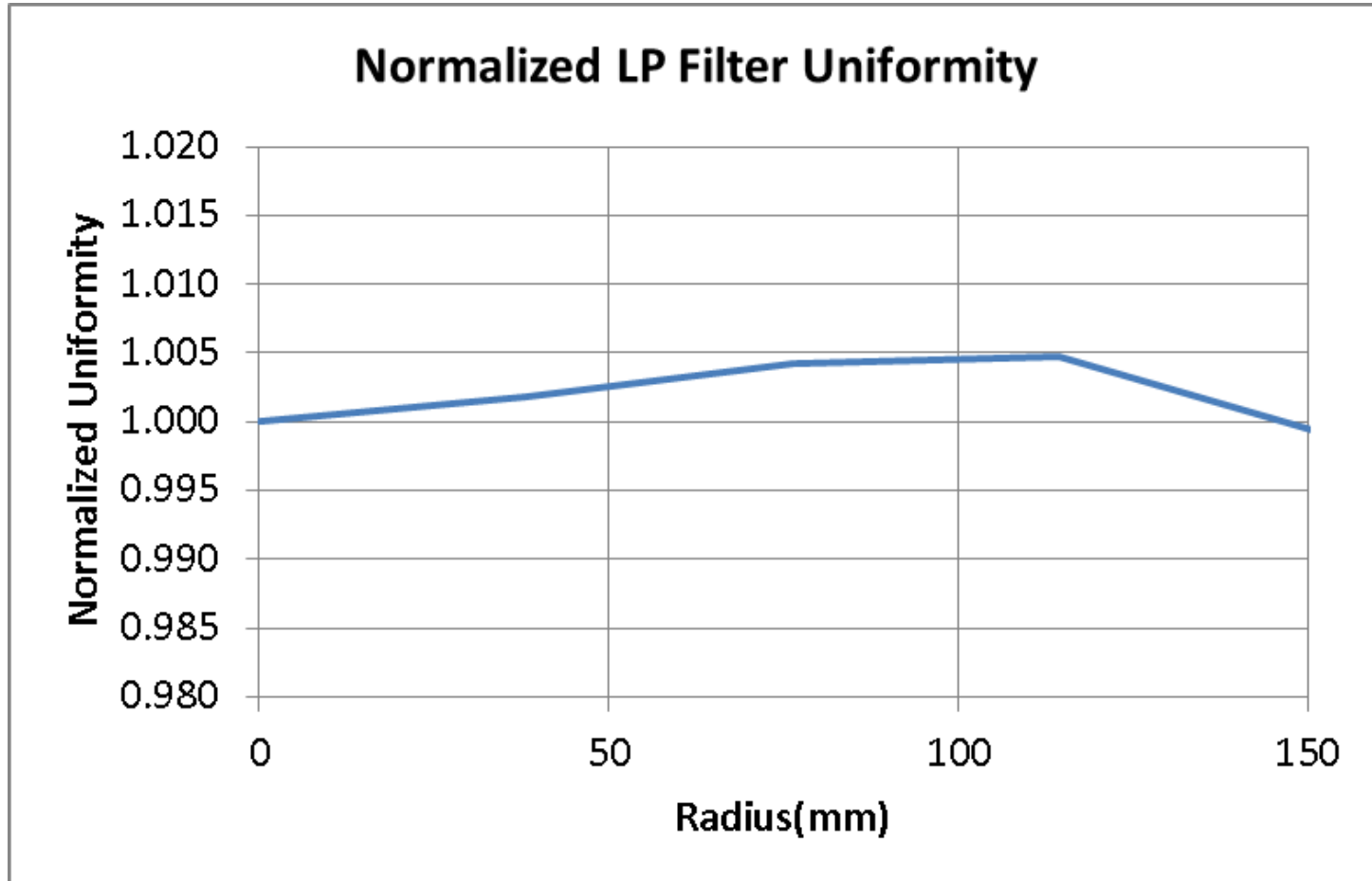
Single layer uniformity across 300mm planets: $< \pm 0.25\%$



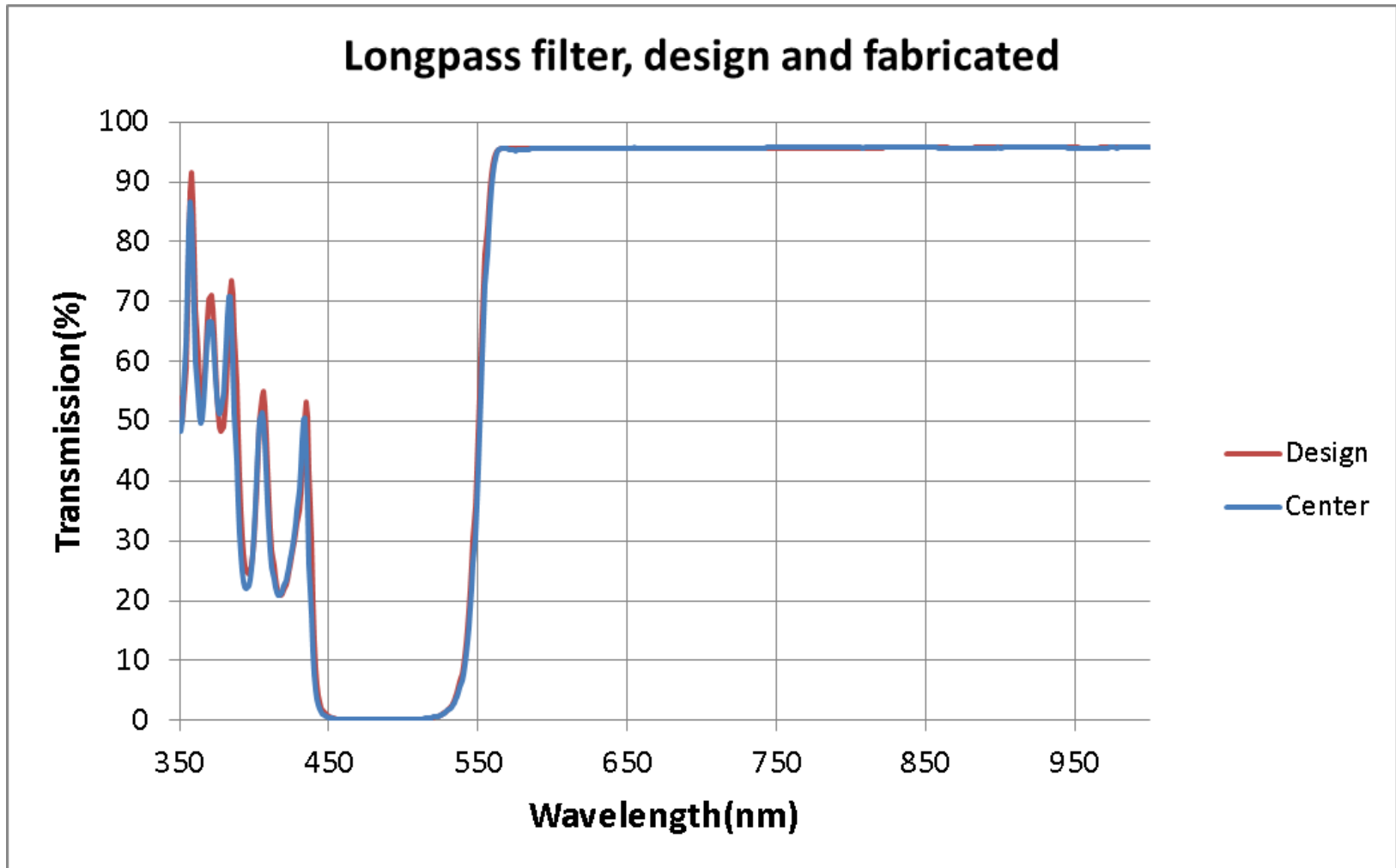
Uniformity of a LP filter across 300mm planets (spectrally measured)



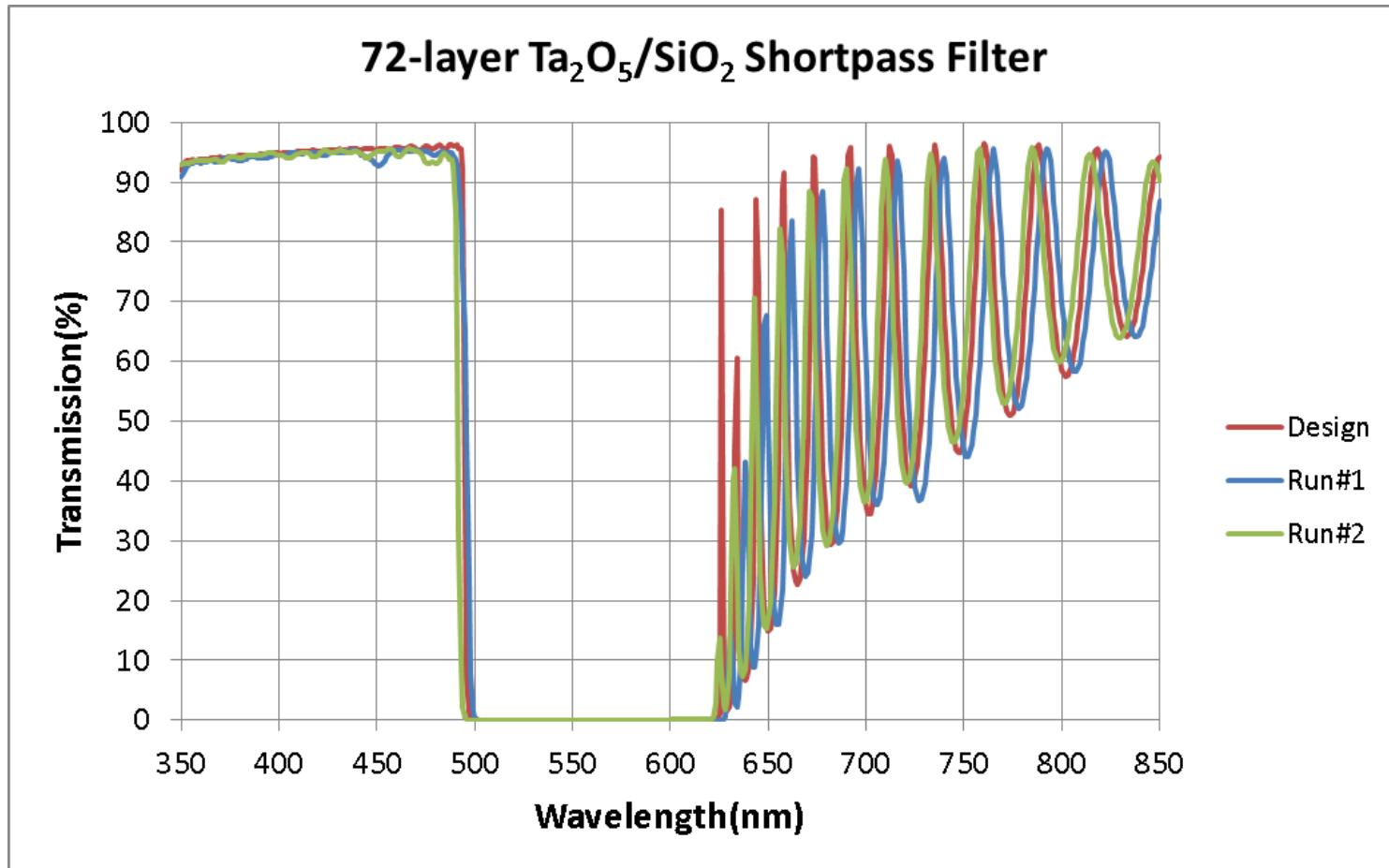
Uniformity of a LP filter across 300mm planets (Normalized)



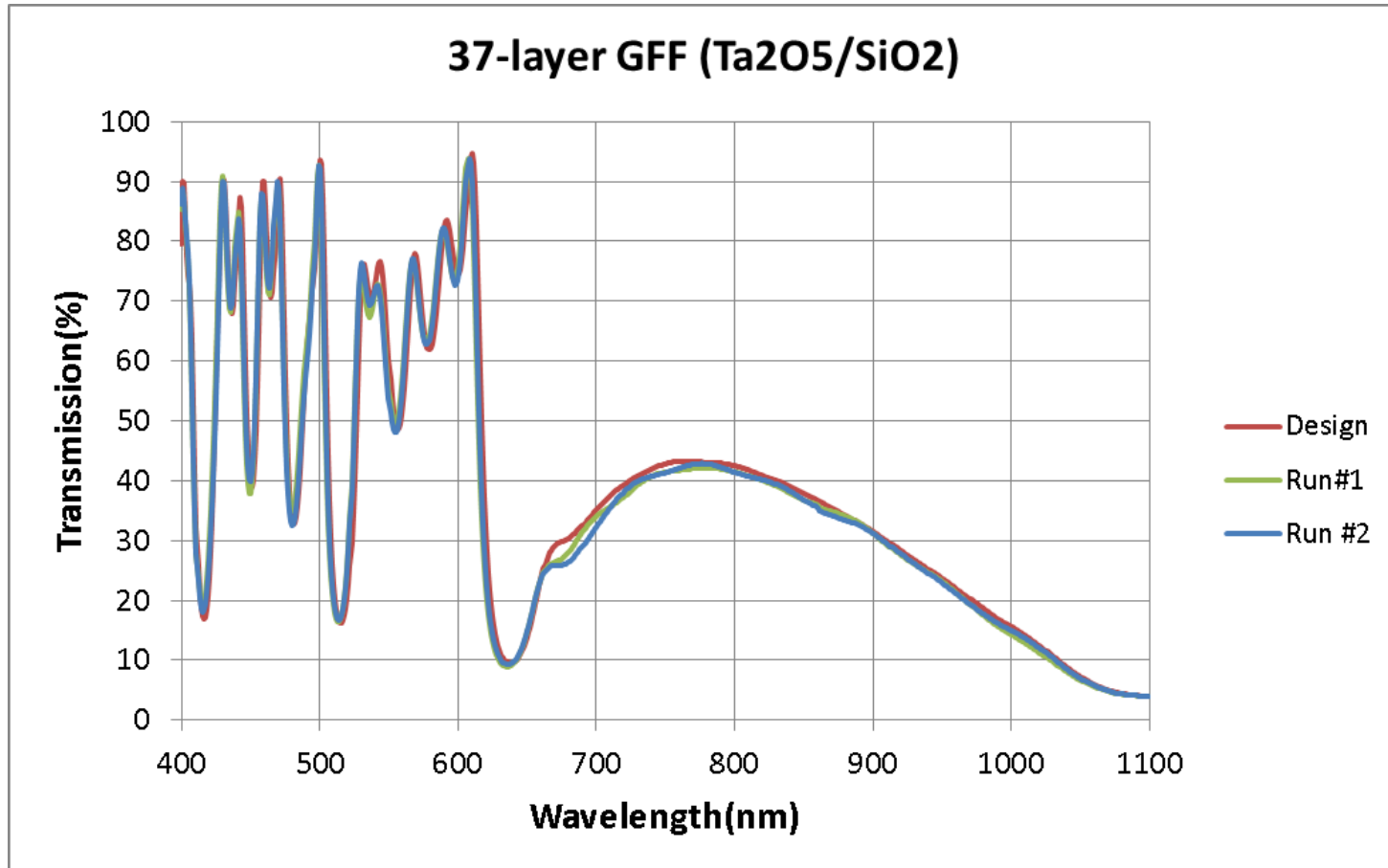
550nm Longpass Filter, 30 layers



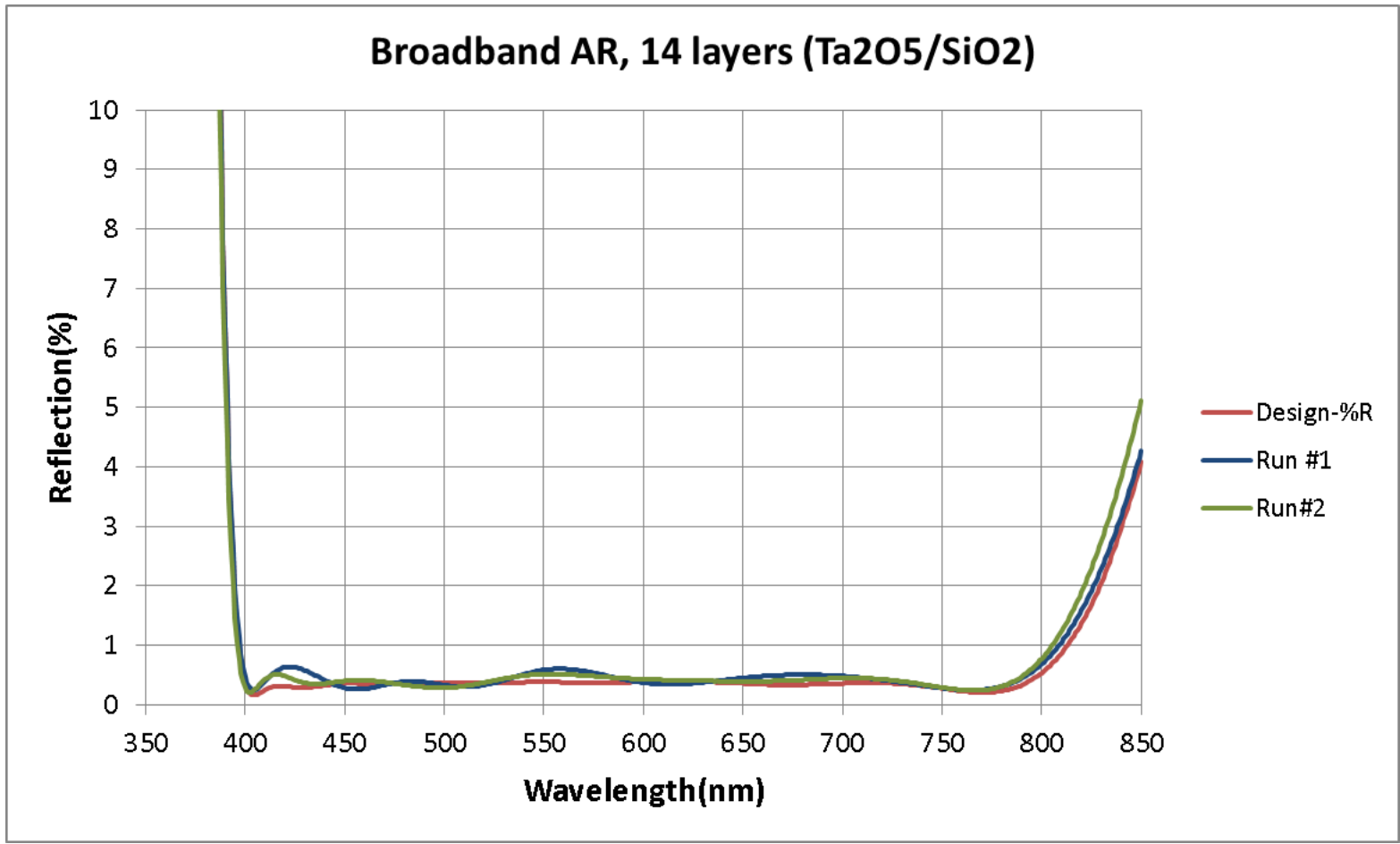
Coating examples : 72-layer SP ($\text{Ta}_2\text{O}_5/\text{SiO}_2$, $5.7\mu\text{m}$) Backside uncoated



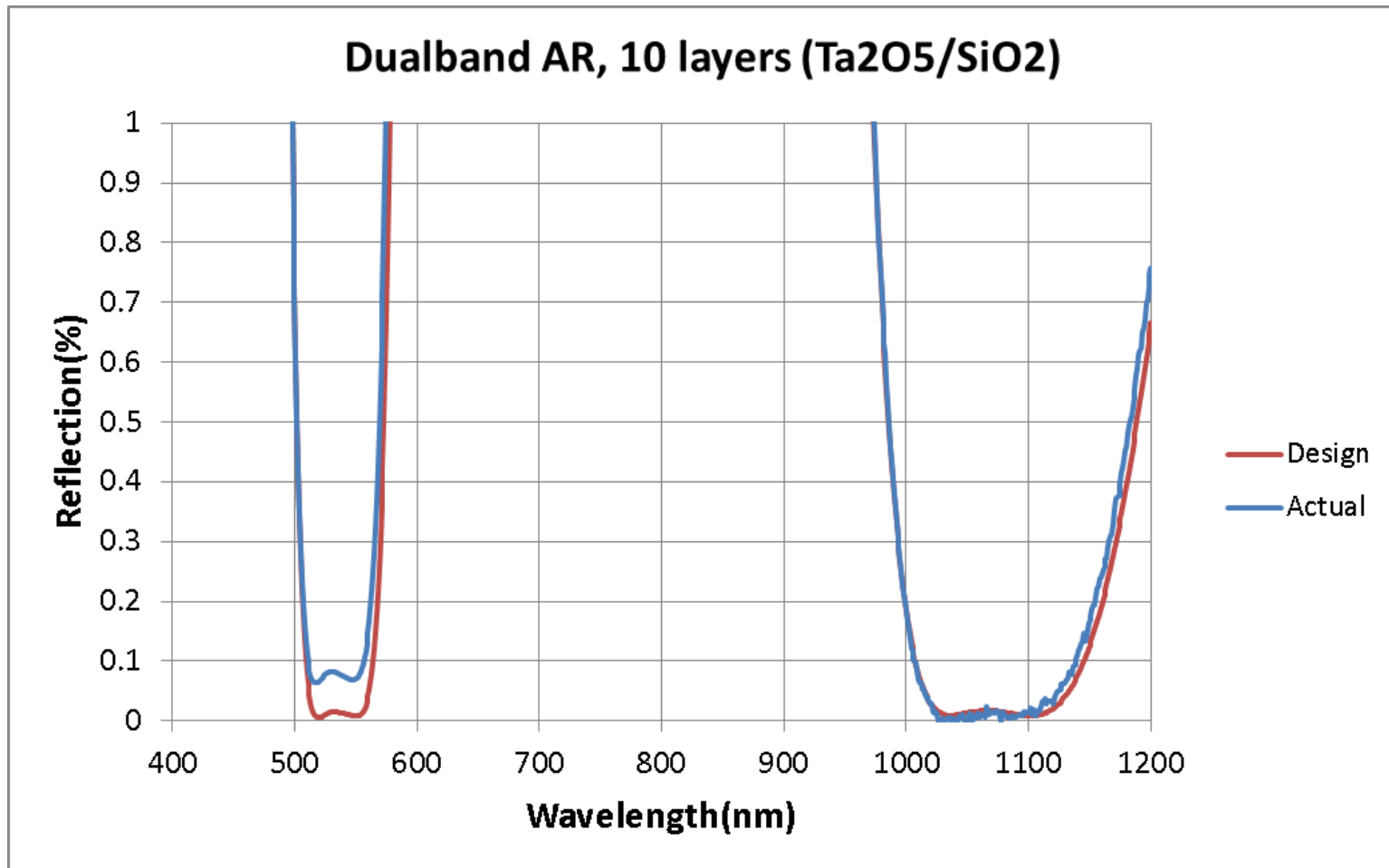
Coating examples : 37-layer GFF (Ta₂O₅/SiO₂, 3.8μm) Backside uncoated



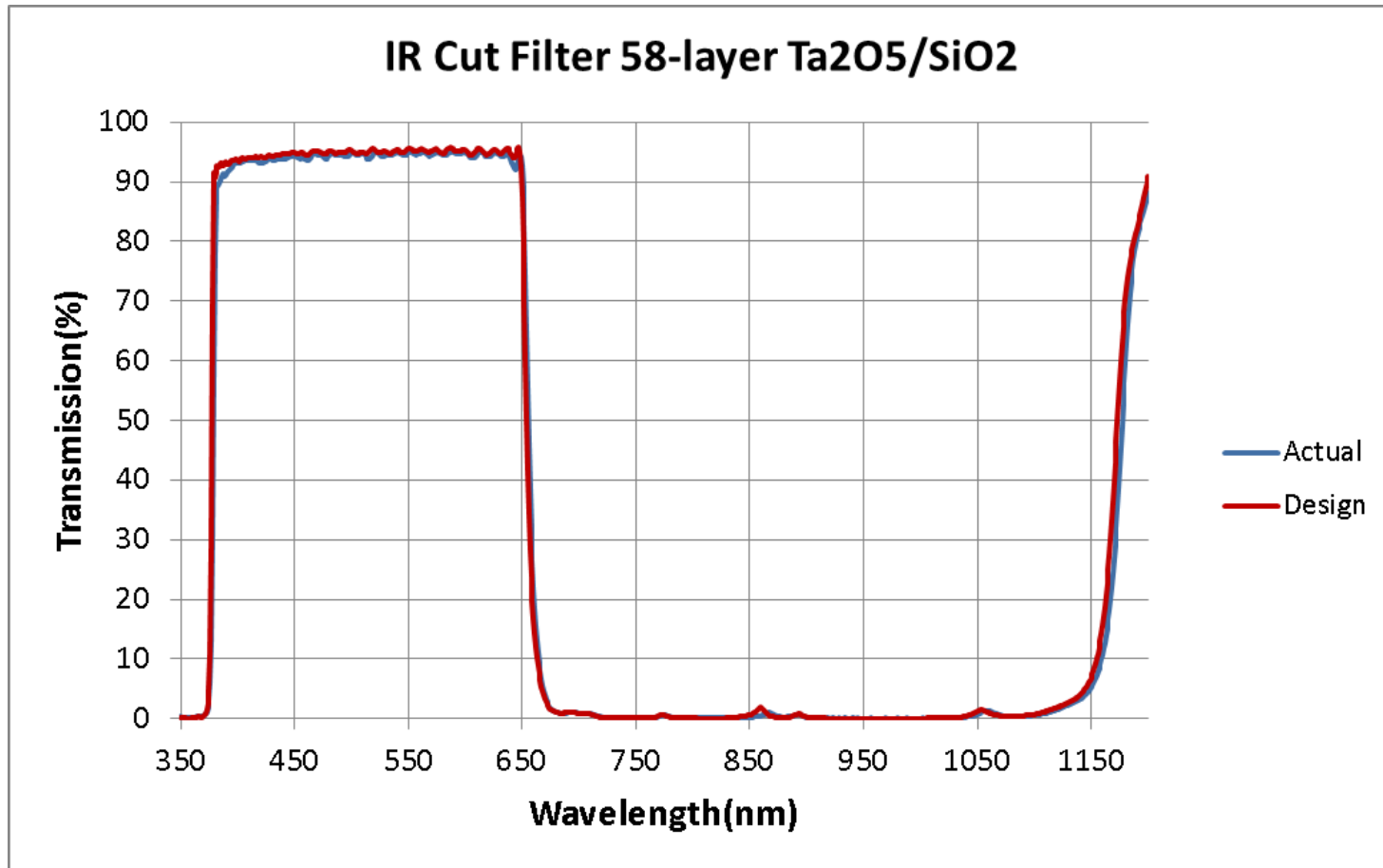
Coating examples: 14-layer BBAR (Ta₂O₅/SiO₂)



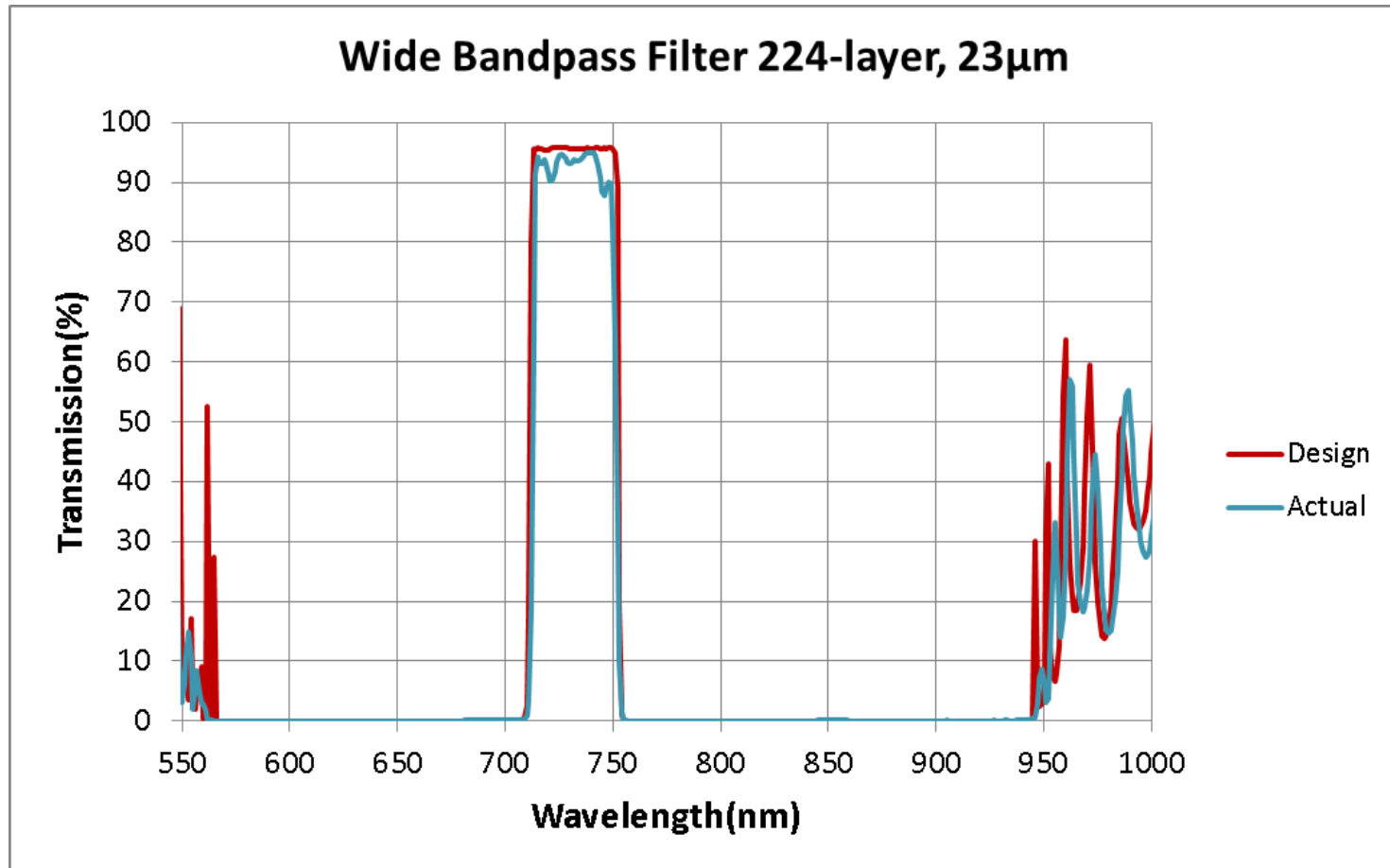
Coating examples: 10-layer Dual-band AR ($\text{Ta}_2\text{O}_5/\text{SiO}_2$)



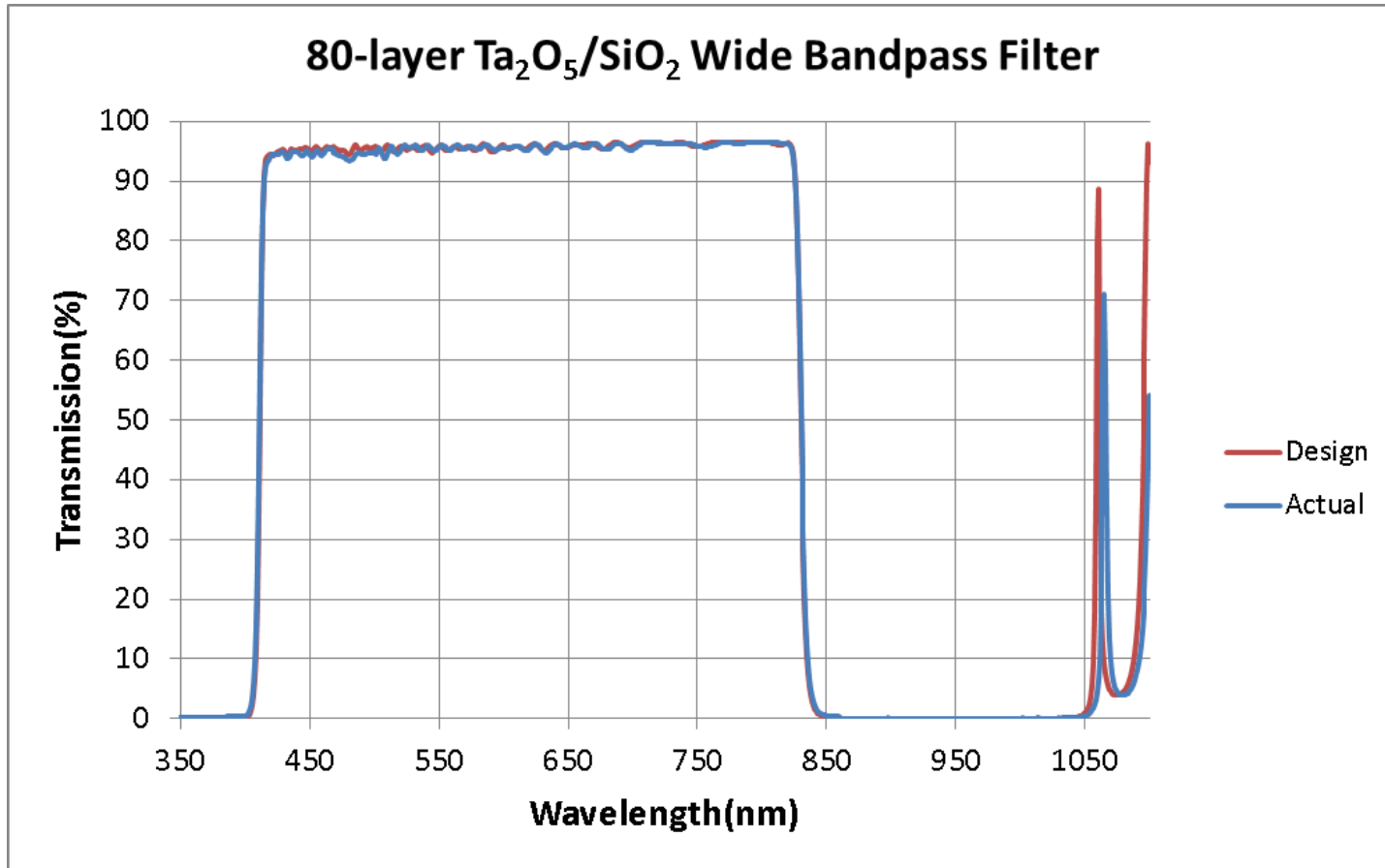
Coating examples: 58-layer IR cut filter ($\text{Ta}_2\text{O}_5/\text{SiO}_2$)



Coating examples: 224-layer WB($\text{Ta}_2\text{O}_5/\text{SiO}_2$, $23\mu\text{m}$) Backside uncoated



Coating examples: 80-layer WB($\text{Ta}_2\text{O}_5/\text{SiO}_2$, $7.1\mu\text{m}$) Backside uncoated



Summary

- Plasma enhanced pulsed DC magnetron sputtering process has been developed
 - Stable and repeatable process: time-power control only
 - Fast deposition rate: Ta_2O_5 : $5\text{\AA}/\text{s}$; SiO_2 : $6\text{\AA}/\text{s}$
 - Dense, low optical loss
 - Large substrate area: six 400mm plates
 - Excellent uniformity: $\pm 0.25\%$ on 400mm planets is achievable