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Novel Ir-X thermal protection coatings designed for extreme aerodynamic heating environment

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Novel Ir-X Thermal Protection Coatings Designed for Aerospace Heating Environment

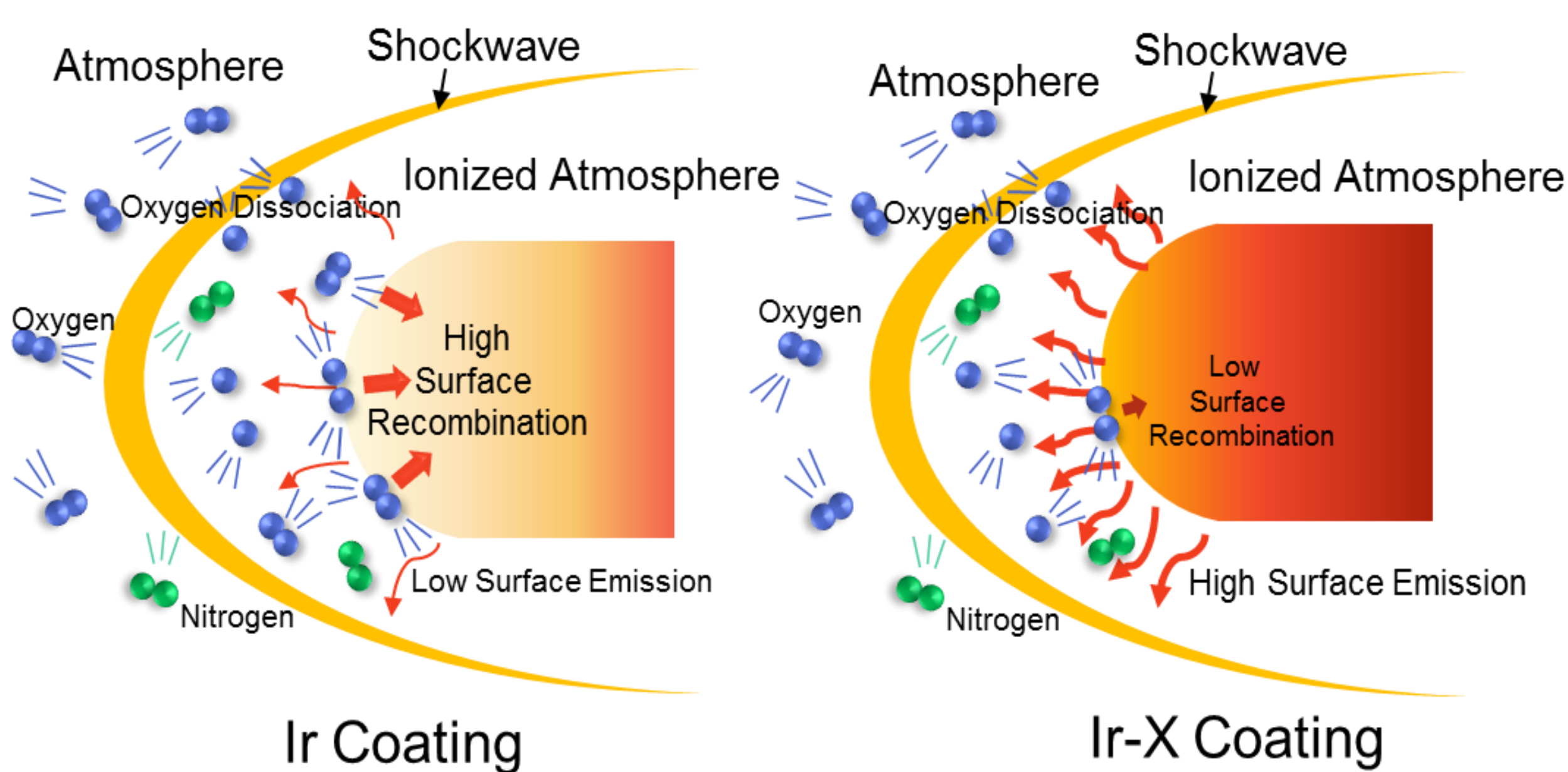
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Abstract

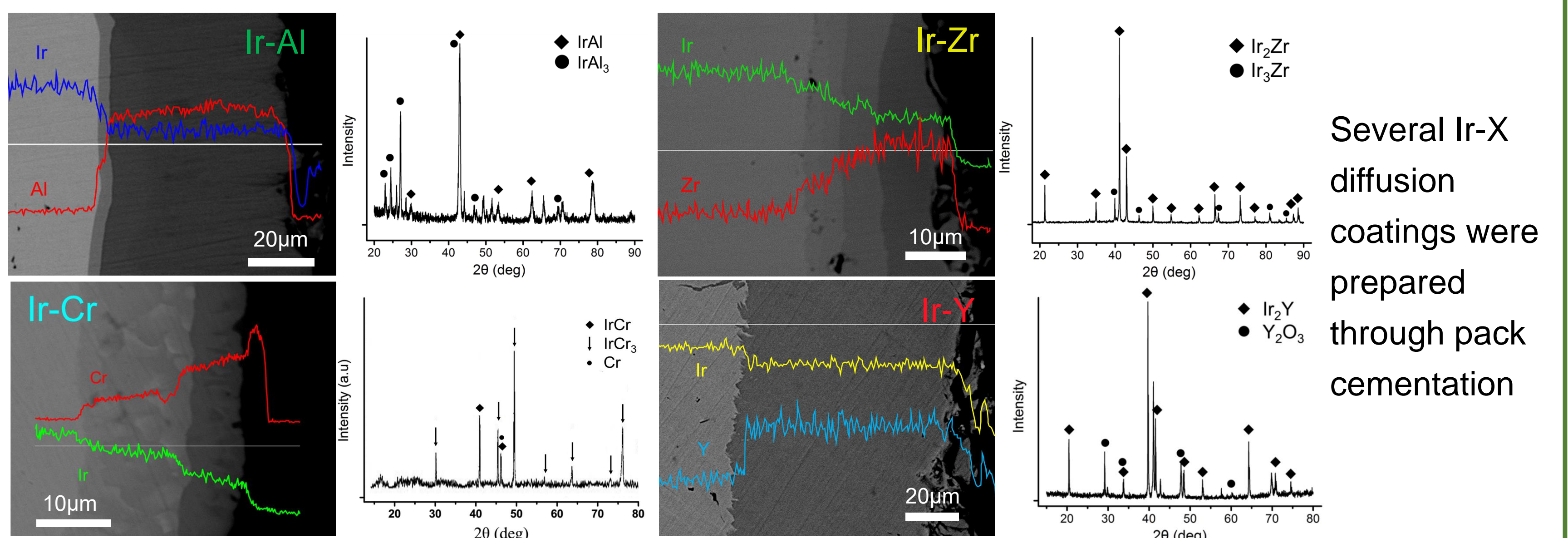
Though being promising in ultra-high temperature application, Iridium coating exhibit low **emissivity**(ϵ) and high **catalycity**(γ) in dissociative atmosphere, which lead to additional heat for hypersonic application. By adding alloy elements X (Al, Cr, Zr...) through pack cementation, Ir-X diffusion coatings were prepared to improve the above properties. Microstructure, element distribution of Ir-X coating were characterized and ϵ and γ of the coatings were measured. The results showed that Ir-X coatings had a much lower catalycity and higher emissivity, and meanwhile decreased surface temperature in dissociative environment.

Graphic Abstract



Results & Discussion

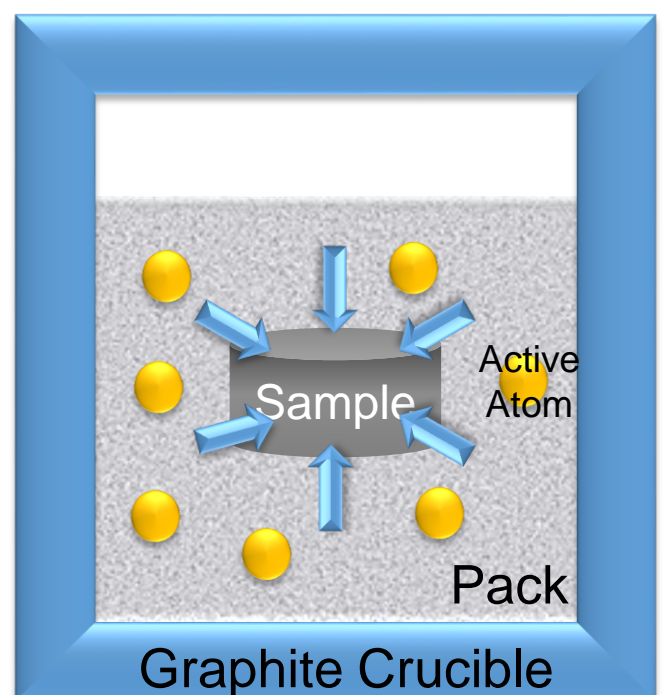
Coating Microstructure



Several Ir-X diffusion coatings were prepared through pack cementation

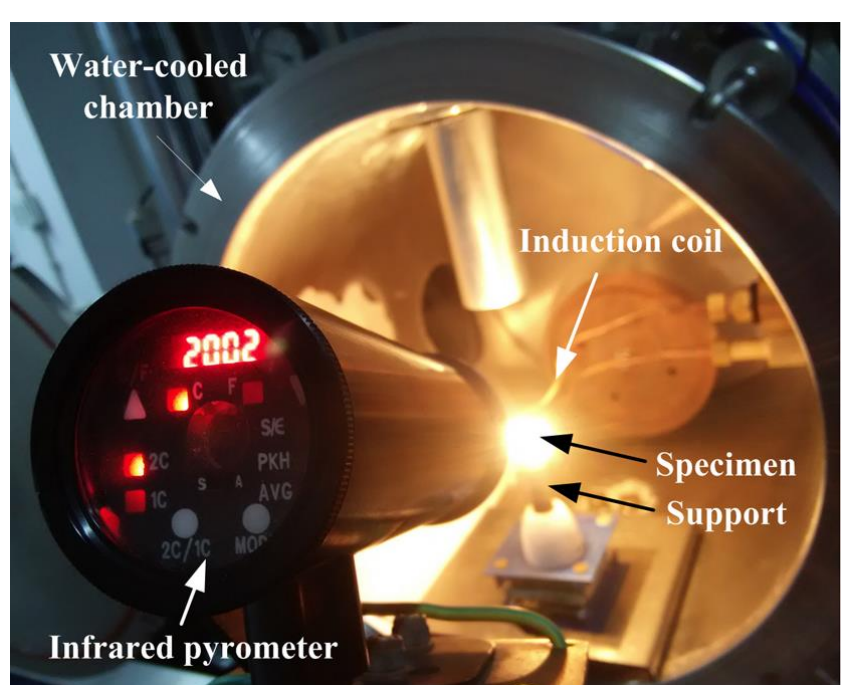
Experiment & Characterization

Pack Cementation Pre-Oxidation



- Element: X=Al, Cr, Zr, Y, Ta
- Pack component: X+XO+NH₄Cl/XCl
- Temperature: 800°C-1600°C

Pre-Oxidation



- Aim: Oxide Scale Formation
- Induction heating
- Infrared thermometry
- 1200°C/30min 1atm

Microstructure Characterization

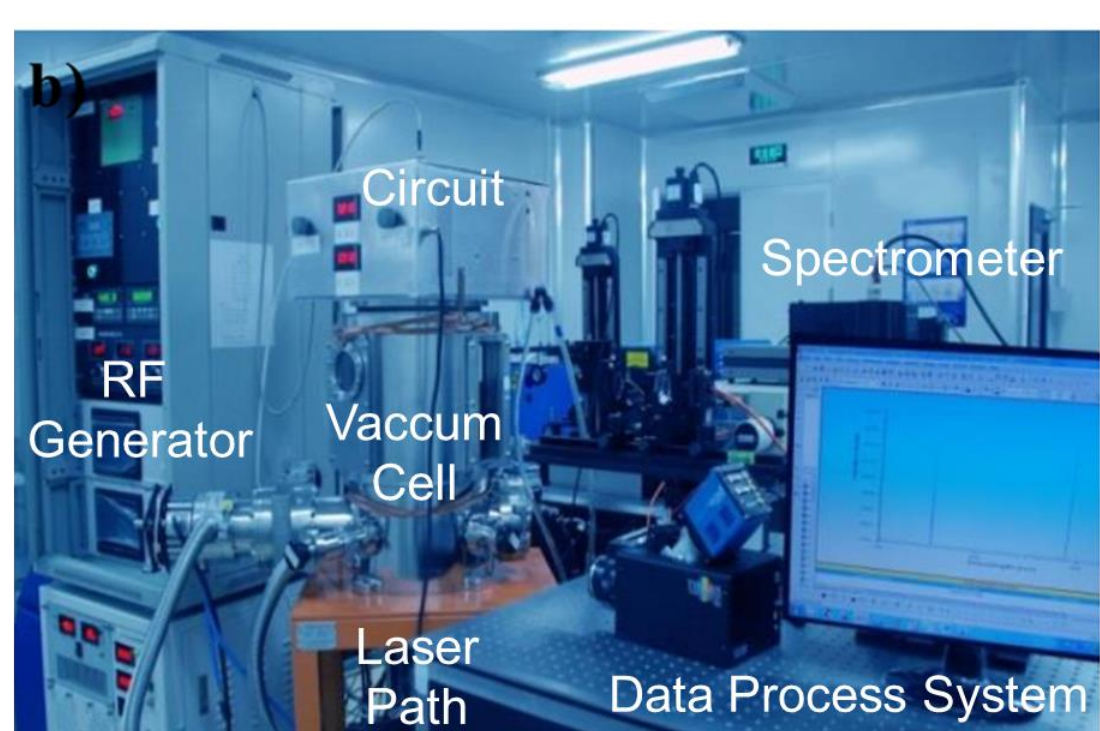
- SEM
- XRD
- EDS

Emissivity Measurement



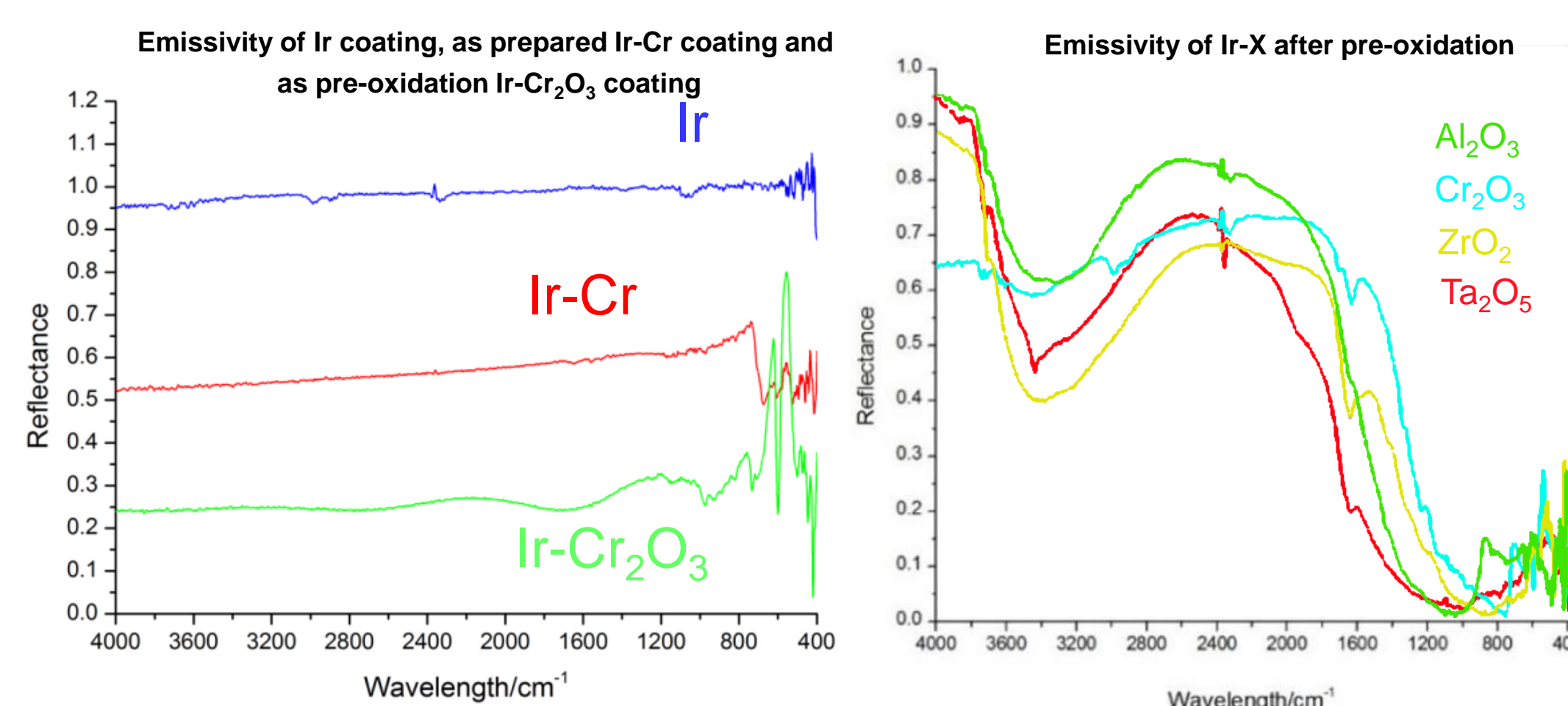
- Bruker Vertex70 FTIR
- Wavelength: 400-4000nm
- Sample: Ir Ir-X Ir-XO

Surface Recombination Test



- RF Generator for O_{atom}
- Laser Sample Heating
- MESOX Method for γ
- Double colorimeter for T

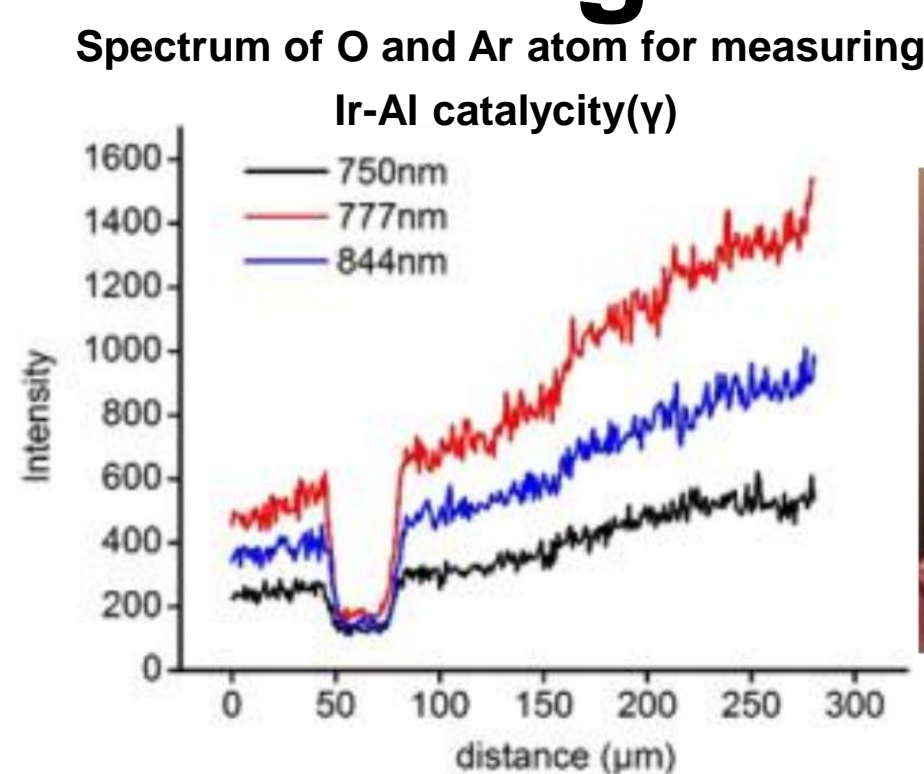
Coating Emissivity



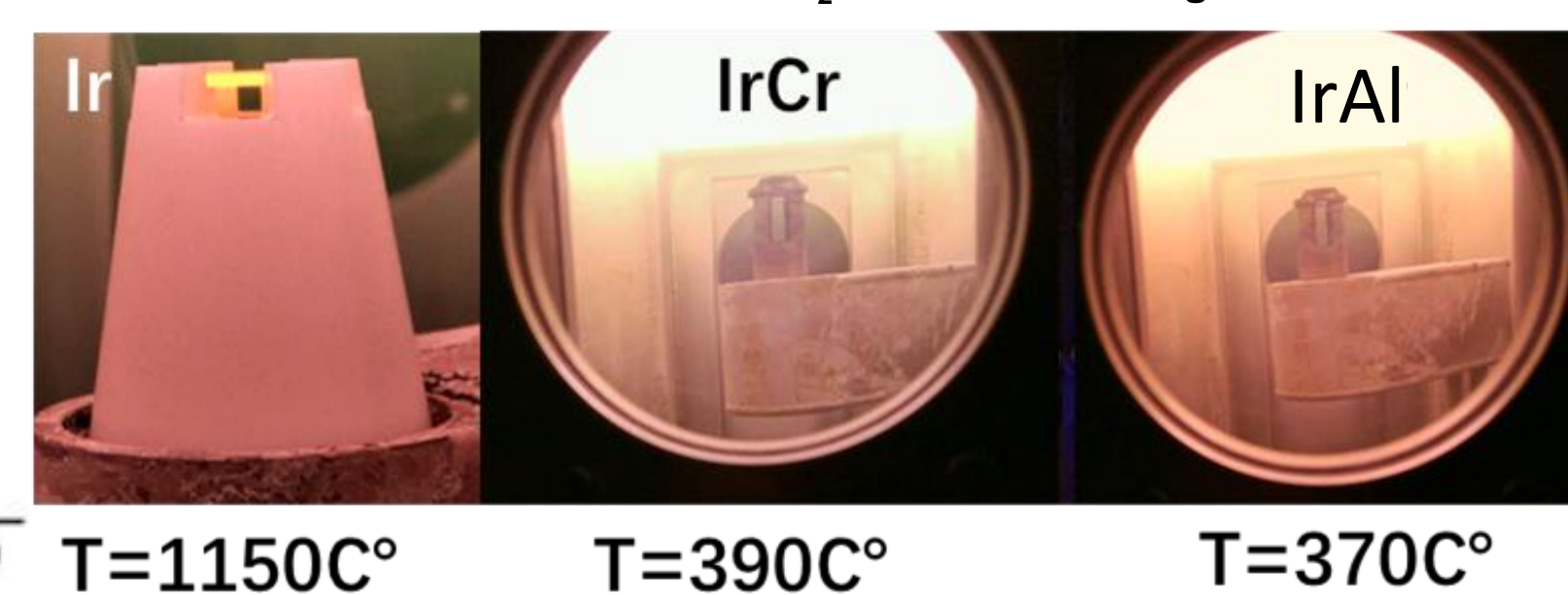
Coating	Emissivity(ϵ)
Ir	0.017
IrCr	0.433
IrAl	0.465
Cr ₂ O ₃	0.723
Al ₂ O ₃	0.759
ZrO ₂	0.547
Ta ₂ O ₅	0.57

※ Measured at Room Temperature

Coating Surface Recombination



Phenomenon and surface temperature of Ir, IrCr and IrZr in dissociative O₂/Ar without heating



Coating	Catalycity(ϵ)
Ir	0.65
Ir	0.7
IrAl	0.004(RT)
IrAl	0.47(1400°C)
Ir-Al ₂ O ₃	0.009(RT)
Ir-Al ₂ O ₃	0.55(RT)

$$\gamma = \left(\frac{I_{Ar}}{I_{Ar}} \right)_{x=L} \cdot \frac{T_s}{T_L} - L \cdot \frac{4D_0}{V \cdot L}$$

Temperature of Ir and Ir-X coating in dissociative O₂/Ar without heating ※ Measured at 20Pa

Coating	Ir	Ir-Al	Ir-Cr	Ir-Zr	Ir-Ta	Ir-Y
Surface T(°C)	1150	370	390	345	424	369

Conclusions

- Ir-X(X=Al, Cr, Zr, Y, Ta) intermetallic coatings with compact single or multilayer scale could be prepared through pack cementation.
- After cementation, Ir-X diffusion coating could largely increase emissivity and decrease catalycity, resulting in a lower surface temperature at dissociative atmosphere.

Acknowledgments

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