The Birefringence Change of Optical Fiber Polarizer with Fe Film in Corrosive Solution

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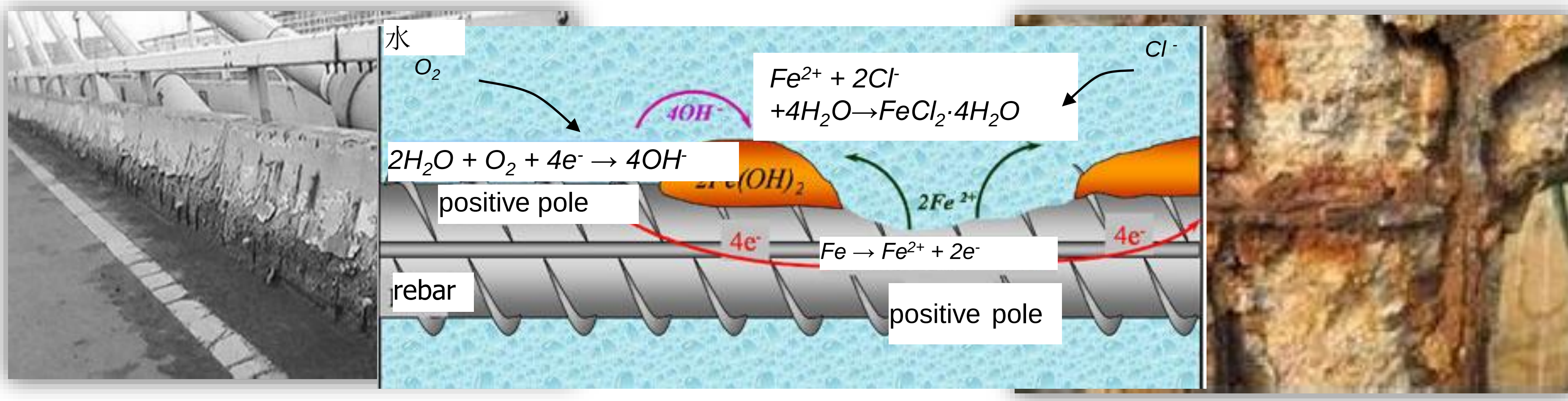
Contents

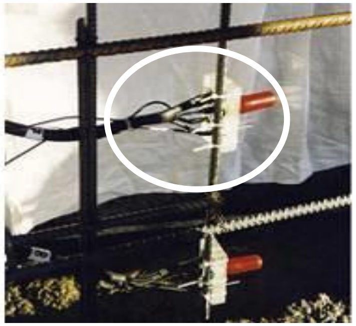
- Background
- Simulation
- Conclusion

BACKGROUND -Requirement

Corrosion of metallic structures → **Severe damages**

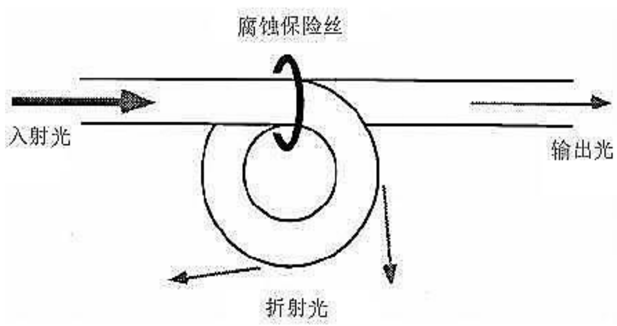


How to monitor Corrosion

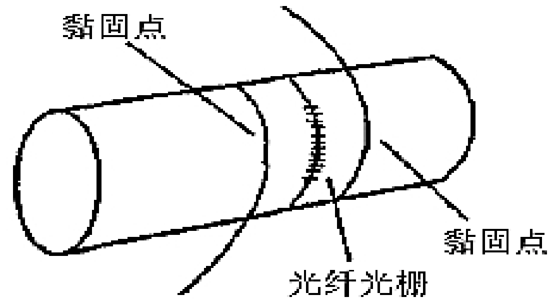


BACKGROUND－Optical fiber sensor

- Bare fiber type (grating) sensors



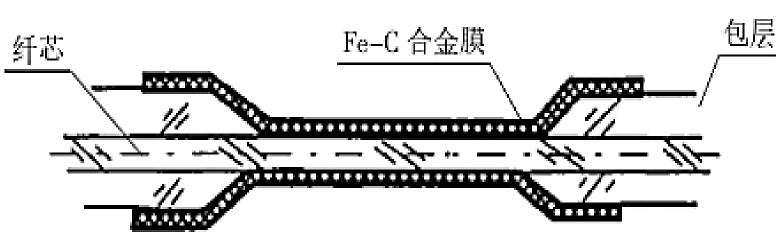
Bare fiber type



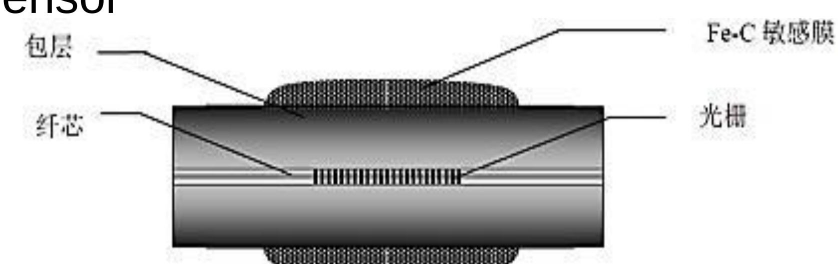
Bare grating type

deficiency： Vulnerable to the interference of external stress, optical fiber (grating) being easy to fracture and low accuracy of sensor.

- Corrosion of sensitive membrane type sensor



Sensitive membrane type optical fiber

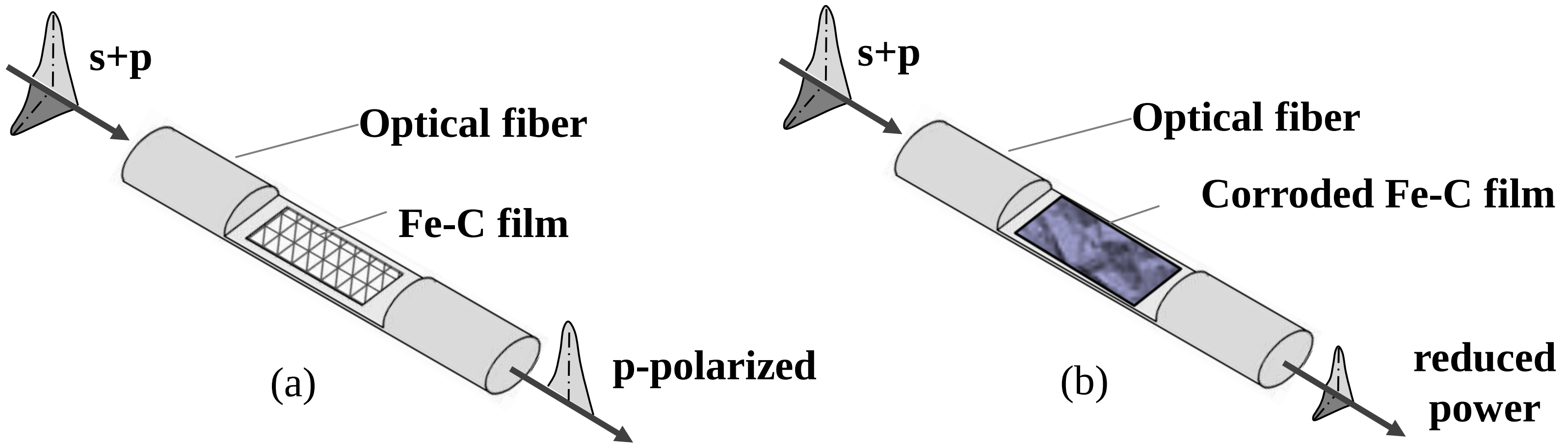


Sensitive membrane type optical grating

deficiency：Sensor sensing features have low repetition rate, corrosion sensitive membrane is easy to fall off 、idea of designing experiment is singleness，Encapsulation is difficult

BACKGROUND —Mechanism

- **A single mode optical fiber is side-polished to obtain a D-shaped optical fiber. D-shaped optical fiber is coated with Fe film to obtain polarization mode.**
- **D-shaped optical fiber is used to monitor the corrosion of Fe film.**



Before Corrosion **After Corrosion**

Chemical changes ⇨ Physical changes

SIMULATION -Methods

- Electromagnetic Waves, Frequency Domain is used as physics interfaces.
- Mode analysis is used to study the simulation.
- The scattering boundary condition is used to reduce the reflection from the boundary.

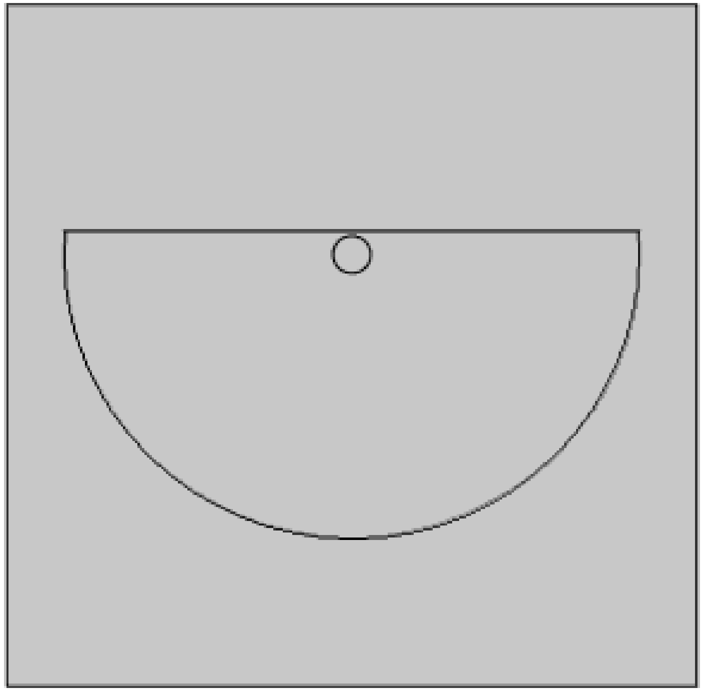


Fig1. geometric graph of simulation

SIMULATION -Equations

Power

$$I = \int J \cdot dS$$

$$P = I^2 R$$

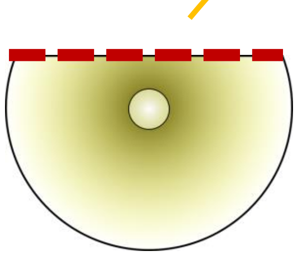
Leakage Power

$$\eta(\mathrm{dB}) = 10\log\left(\frac{P_{Leakage}}{P_{Total}}\right) = 10\log\left(\frac{I^2_{Leakage}}{I^2_{Total}}\right)$$

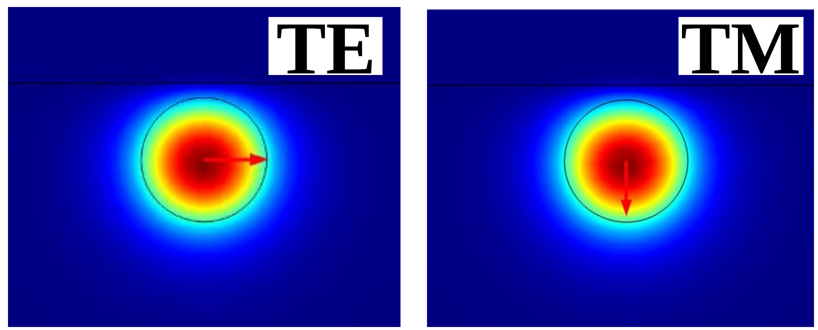
Extinction Ratio

$$\mathrm{ER}(\mathrm{dB}) = 10\log\frac{P_{TE}}{P_{TM}} = 10\log\frac{I^2_{TE}}{I^2_{TM}}$$

SIMULATION -Two models



Model A



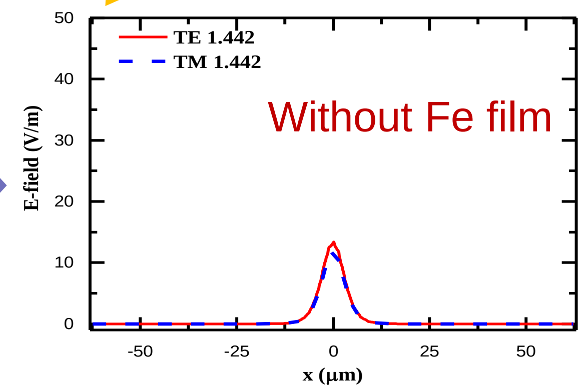
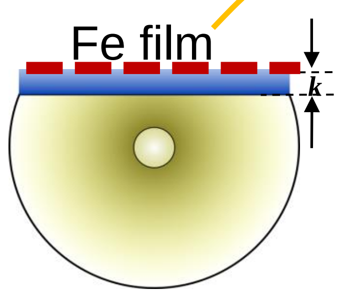
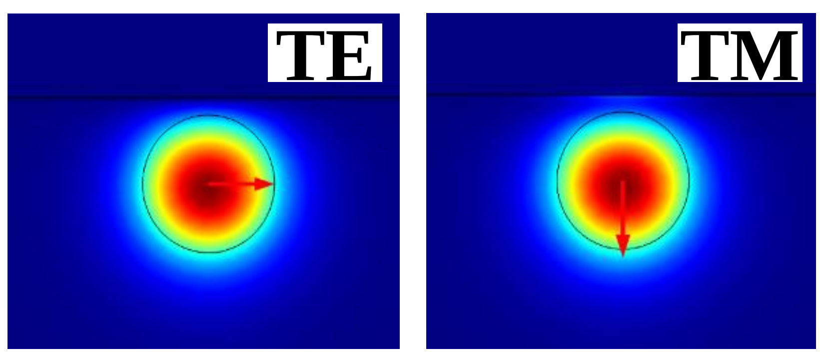


Fig2. D-shaped optical fiber **without** Fe film



Model B



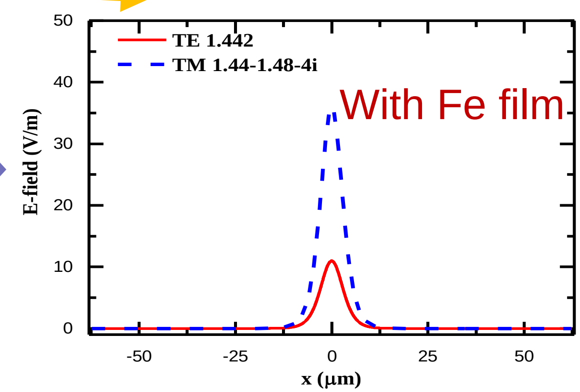
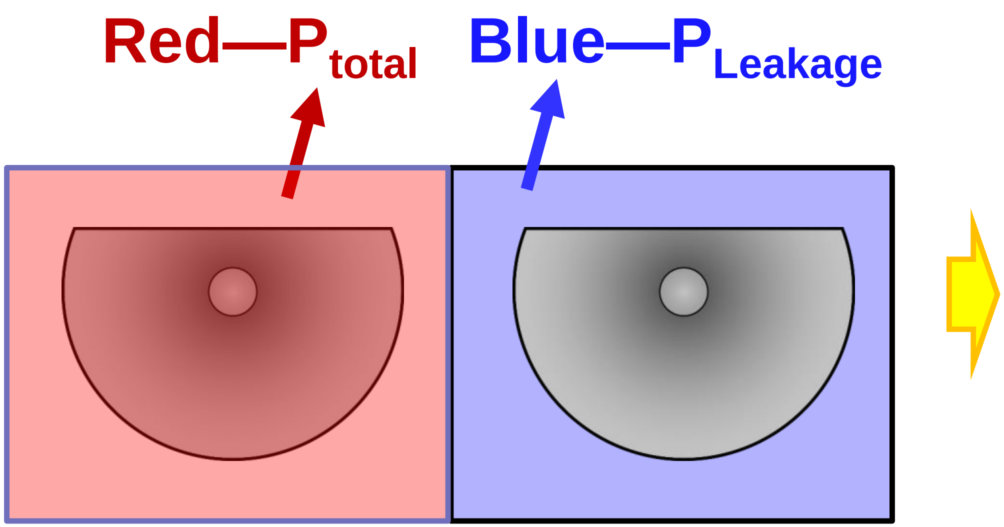


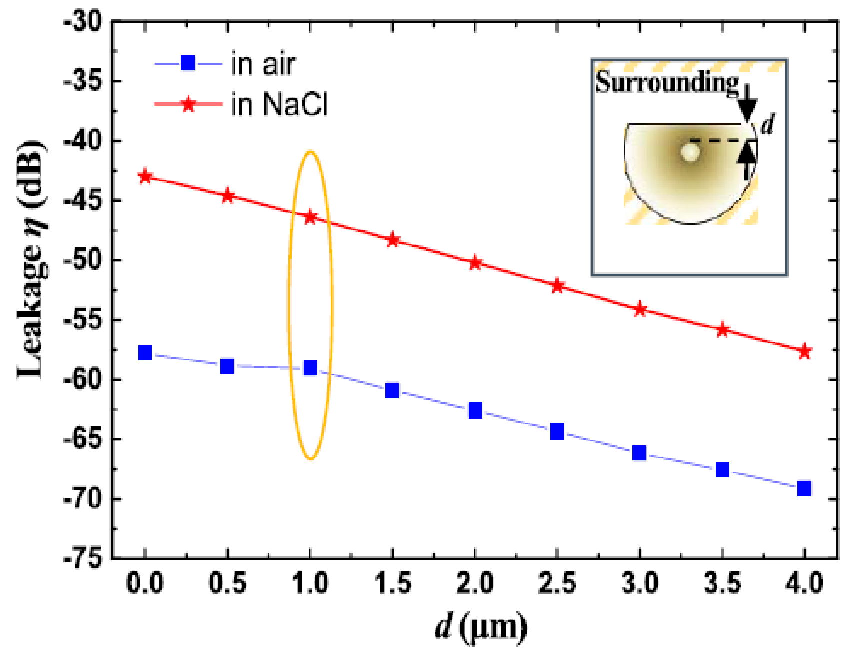
Fig3. D-shaped optical fiber **with Fe** film

SIMULATION －Power Leakage

$$\eta(\mathrm{dB}) = 10\log\left(\frac{P_{Leakage}}{P_{Total}}\right) = 10\log\left(\frac{I_{Leakage}^2}{I_{Total}^2}\right)$$



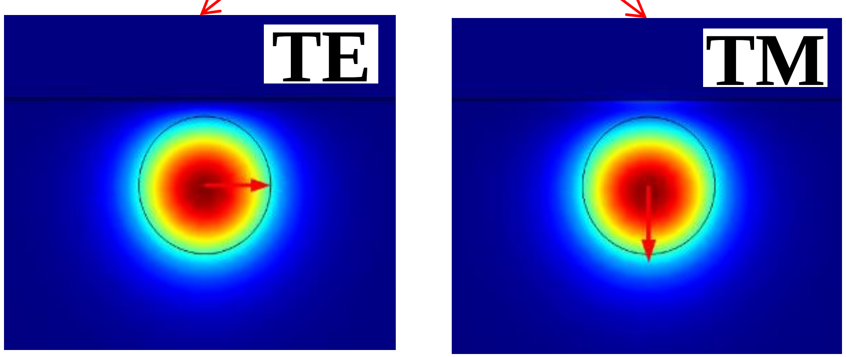
Model A



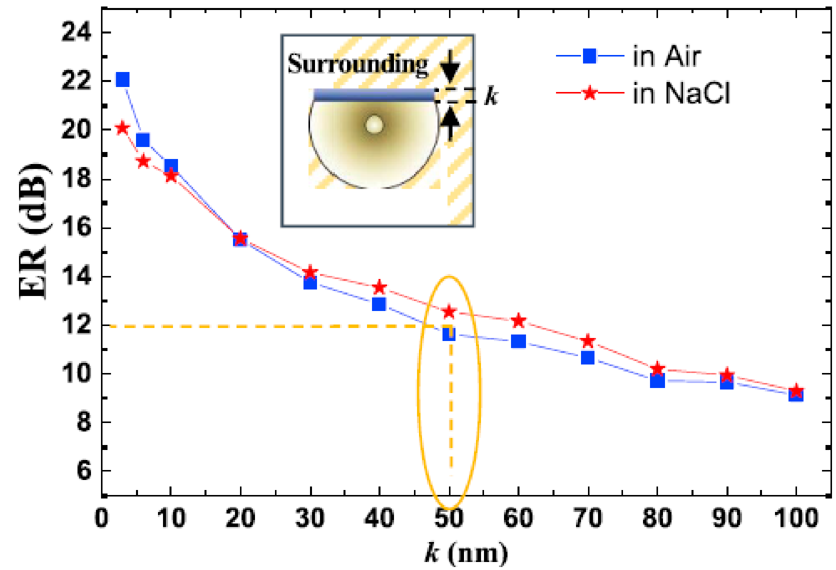
Leakage power vs Polishing depth

SIMULATION －ER value

$$\mathrm{ER(dB)} = 10\log\frac{P_{TE}}{P_{TM}} = 10\log\frac{I_{TE}^2}{I_{TM}^2}$$

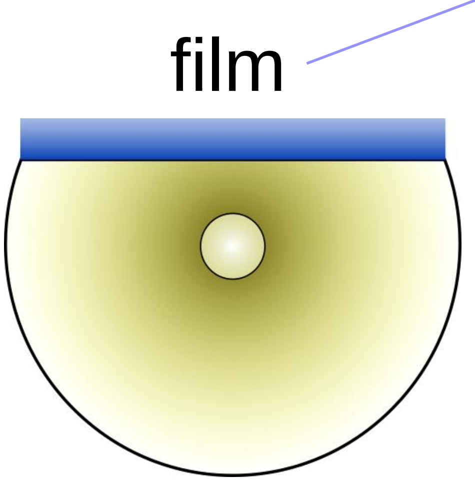


Model B



ER value vs thickness of Fe film

SIMULATION – Corrosion process



Fe

↓

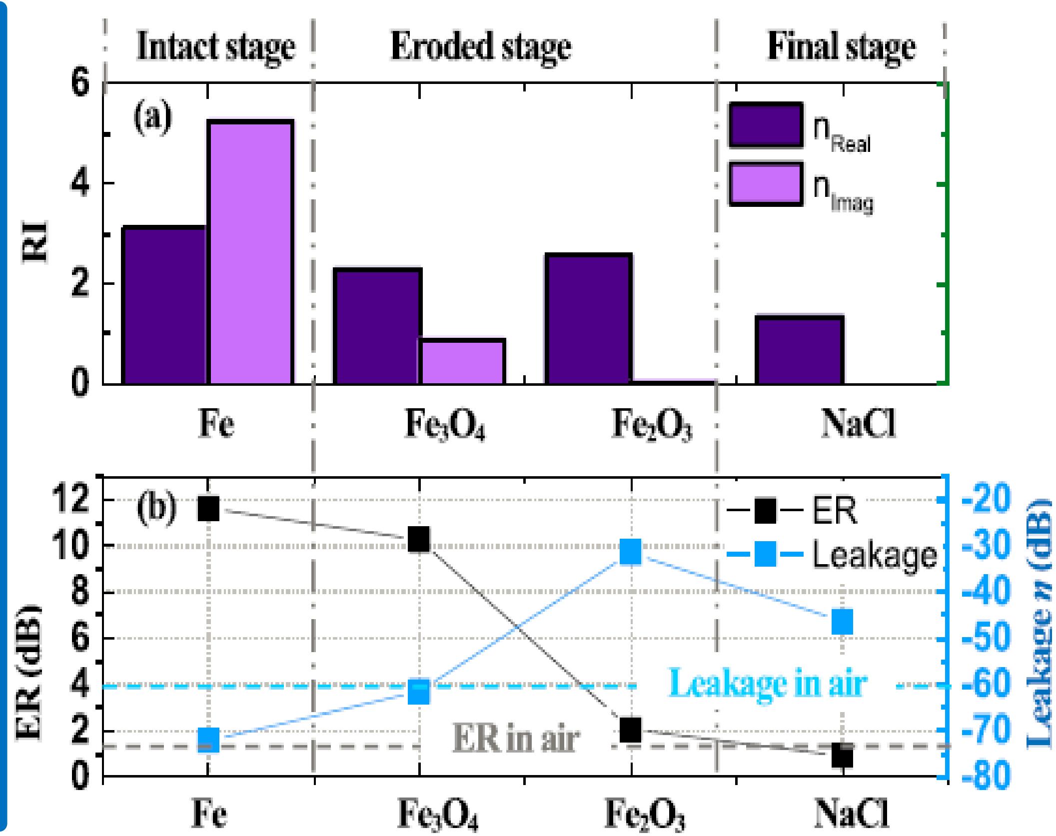
Fe_3O_4

↓

Fe_2O_3

↓

NaCl



CONCLUSIONS

- D-shaped optical fiber can be coated with Fe film to obtain polarization mode.
- With the increasing of side-polished depth, leakage power will decrease.
- With the increasing of the Fe-film’s thickness, ER value will decrease.
- With the corrosion of Fe-film, ER value will decrease.

Thanks

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