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Comprehensive evaluation factor of optoelectronic properties for transparent conductive metallic mesh films

Key words: Metallic mesh; Technique for order preference by similarity to ideal solution (TOPSIS); Entropy weight (EW); Comprehensive evaluation; Transparent conductive films

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Motivation

1. Different meshes have different diffraction characteristics; at the same time, the electromagnetic interference shielding effectiveness (EMI SE) and the optical transmittance of metallic meshes are mutually restricted.

2. To achieve the optimal optoelectronic properties (EMI SE, optical transmittance, and stray light uniformity) for metallic meshes, it is necessary to conduct a comprehensive evaluation with different parameters based on these optoelectronic properties.

3. So far, there have been few studies on this aspect.

Main idea

A comprehensive evaluation factor *Q* is proposed to evaluate the mesh in a simple and efficient way.

Comprehensive evaluation factor *Q*: $Q = \sqrt{T_0} \cdot S \cdot U$

T_0: zero-order optical transmittance

S: EMI SE

U: stray light uniformity

$$U = \frac{X}{D \cdot I} = \frac{I \cdot \left(\sqrt{T_0} - T_0\right)}{D \cdot I} = \frac{\sqrt{T_0} - T_0}{D}$$

X: whole intensity of stray light

I: incident optical intensity

D: maximum of normalized high-order diffraction

Method

1. A comprehensive evaluation factor *Q* is proposed to evaluate the optoelectronic properties (zero-order optical transmittance, shielding effectiveness, and stray light uniformity) of the metallic mesh.

2. The typical comprehensive evaluation process of the technique for order preference by similarity to ideal solution (TOPSIS) based on the entropy weight is used to verify the validity of *Q*.

3. Metallic meshes with different structures under various parameters are compared by *Q* to verify the applicability of *Q*.

Major results

1. Using TOPSIS to evaluate the single-layer square metallic mesh with high optical transmittance and strong shielding (SSMM-HTSS) with different parameters

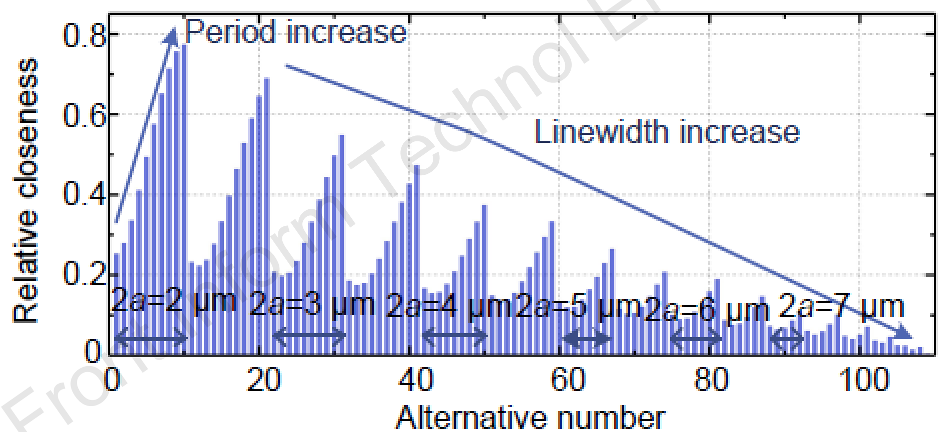

Fig. 3 Relative closeness bar chart of 109 SSMM-HTSS alternatives

The largest period with the smallest linewidth for SSMM-HTSS reveals the best comprehensive evaluation result.

Major results (Cont’d)

2. Comparing the trend of *Q* values with the evaluation results of TOPSIS to verify the effectivity of *Q*

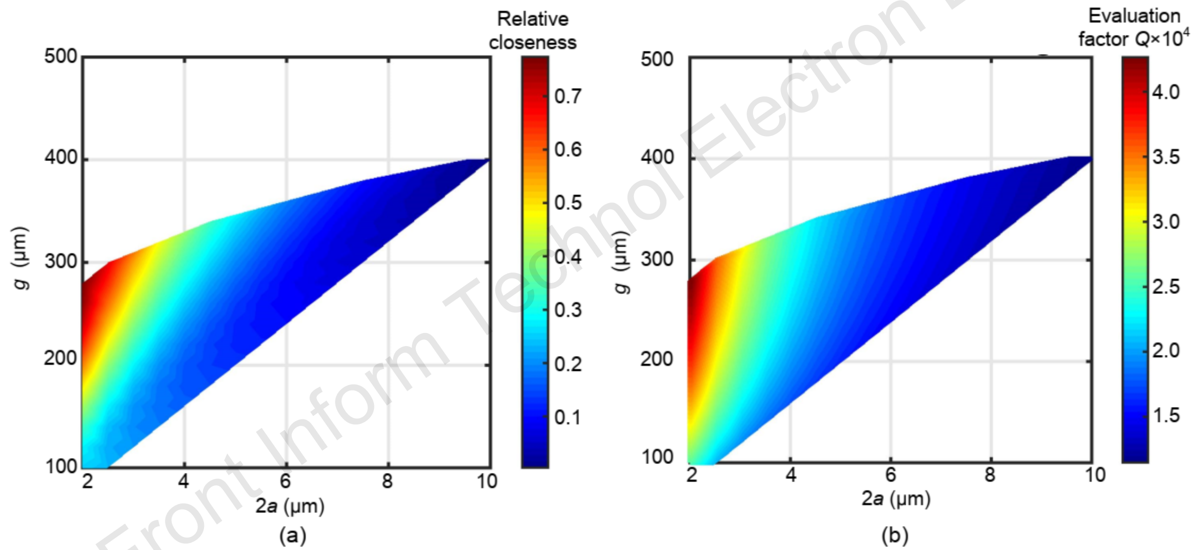

Fig. 4 Relationship between relative closeness and the design parameters of SSMM-HTSS (a) and between evaluation factor *Q* and the design parameters of SSMM-HTSS (b)

The trend of the *Q* value agrees well with the evaluation results of TOPSIS, which verifies the effectivity of *Q*.

Major results (Cont'd)

3. Using *Q* to evaluate five different metallic meshes at the same fabricated linewidth and optical transmittance

Table 2 Comprehensive evaluation factor *Q* for five different metallic meshes

Metallic mesh	T_0 (%)	S (dB)	U	Q	Reference
Square metallic mesh	90.25	26.92	102.26	2484.437	Kohin et al. (1993)
Ring metallic mesh	90.25	22.08	225.78	4499.163	Tan and Lu (2007)
Nested multi-ring array metallic mesh	90.25	20.13	535.42	9727.149	Wang HY et al. (2017)
Triangular ring mesh with rotated sub-rings	90.25	20.69	670.96	12 528.65	Lu ZG et al. (2016)
Interlaced multi-ring metallic mesh	90.25	21.42	960.93	18 576.27	Lu X et al. (2019)

Q is suitable for evaluating meshes with different shapes.

Conclusions

1. A comprehensive evaluation factor *Q* constructed from the three main criteria for the metallic mesh has been proposed, which can be used to quantitatively evaluate the optoelectronic properties of the metallic mesh with different parameters.

2. *Q* is used to evaluate five different metallic meshes at the same fabricated linewidth and optical transmittance, which shows that *Q* is suitable for evaluating meshes with different shapes.

3. Due to its simple form and direct relation to optoelectronic property criteria, *Q* has great significance in the design and application of conductive metallic meshes.

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