**Abstract:** In this paper, we report on the statistical analysis of the THz signatures of identically realized diffraction grating-based tags by repeatable measurements. The correlation between the different signatures is analysed and the global error rates are evaluated from the statistical distributions and we show that error rates of 2.75% can be reached.

**INTRODUCTION**

The Terahertz Identification (THID) is currently a growing research for security and anti-counterfeiting applications [1]. Recently, we demonstrated the possibility to discriminate tags structures based on a 1D diffraction grating engraved on the surface of a dielectric material by varying the geometrical parameters of the grating [2]. In this study, we focus on the statistical analysis of the THz identical tags signatures to evaluate the correlation between each other. The tag structure we propose here is schemed in Fig. 1. This structure acts as a dielectric waveguide coupled with a 1D diffractive grating which presents a unique signature in the THz domain. In this study, we realized 44 identical tags using the same protocol. Due to the randomness of the fabrication process, each tag presents tiny variations that will be used for authentication.

**STATISTICAL ANALYSIS**

In order to address authentication process, we did 100 measurements of each tag at the same position. Then, we compute all the correlation coefficients combinations between measurements on the THz signatures and their 1st and 2nd derivatives which are used to highlight the fast variations (m-lines) in the signatures, and we plot the probability densities (see Fig. 2) associated to the intra-measurements (i.e. measurements of the same tag) and the inter-Tags, (i.e. measurements of a tag compared to another one). In Fig. 2, we define two parameters used for the authentication process: the True Positive (TP) and the False Positive (FP) rates. Then, we compute the ROC curve and we calculate the Equal Error Rate (EER) which are typically used in classical authentication systems comparison [3]. Finally, to evaluate the global performance of the authentication method, we also compute the Area Under Curve (AUC), which represents the area under the ROC curve, as a more robust metric.

![Fig. 1. a, Picture of the tag dedicated to authentication. b, Scheme of the proposed structure.](image)

**Table 1.** Error rates calculated on signatures and their 1st and 2nd derivatives using EER and AUC metrics.

<table>
<thead>
<tr>
<th></th>
<th>1st derivatives</th>
<th>2nd derivatives</th>
</tr>
</thead>
<tbody>
<tr>
<td>EER</td>
<td>9.05%</td>
<td>8.6%</td>
</tr>
<tr>
<td>AUC</td>
<td>4.5%</td>
<td>2.75%</td>
</tr>
</tbody>
</table>

**CONCLUSION**

In this study, we demonstrated the possibility to authenticate identical diffraction grating tags structures simply by using the tiny variations during the fabrication process. We showed that error rates of 2.75% can be reached considering the AUC metric calculated on the 1st derivatives of the THz tags signatures for authentication applications.

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**REFERENCES**