# Modified State Enhanced Actinometry for Measuring Atomic Oxygen Density in a Micro-Scaled Atmospheric Pressure Plasma Jet

K. Poonsawat, E. Wagenaars
*York Plasma Institute, School of Physics, Engineering and Technology, University of York, UK*

**Abstract:** A modified version of State Enhanced Actinometry (SEA) is presented, using Bayesian Interference for matching experimental and theoretical data and including cascading effects in the SEA model. Additionally, an alternative He(3s $^1S \rightarrow 2p\ ^1P$), 728.1 nm, line is considered instead of the He(3s $^3S \rightarrow 2p\ ^3P$), 706.5 nm, line. O density and mean electron energy are determined in a micro-scaled atmospheric pressure plasma jet (μAPPJ).

## 1. Introduction

Actinometry is a simple, non-invasive method for measuring O density. State enhanced actinometry (SEA) [1] was recently developed, improving on previous actinometry methods.

Despite the success of SEA, there are some issues that our work aims to address. The effects of adding a term for cascading emission and the use of an alternative helium line in our modified SEA methods are investigated.

## 2. Methods

The plasma source used is a μAPPJ [2]. It is powered by a 13.56 MHz RF power supply and operated in a mixture of 1 slm He, 5 sccm $O_2$ and 1 sccm Ar.

Emission is detected by using an optical spectrometer. The emission lines of interest are at the wavelengths of 706.5, 728.1, 750.4 and 844.6 nm, corresponding to He(3s $^3S \rightarrow 2p\ ^3P$), He(3s $^1S \rightarrow 2p\ ^1P$), Ar($2p_1 \rightarrow 1s_2$) and O(3p $^3P \rightarrow 3s\ ^3S$) respectively.

In the results, the original SEA method [1] is indicated as SEA(original). The model where the 728.1-nm He line is used instead of the 706.5-nm He line is labelled SEA*(original). The SEA(modified) is the original SEA model, with the addition of cascading emission and SEA*(modified) has both the alternative He line and cascading emission included.

The O density and mean electron energy are found from a crossing point of the two intensity ratios in a figure of mean electron energy versus dissociation fractions. Here, Bayesian Interference is applied to help find that crossing point more robustly.

## 3. Results and Discussion

The O density from the SEA models is presented in fig 1 together with TALIF results from literature.

With considering cascading emission, SEA(modified) shows that the O density is increased by 40%-60% approximately when compared with that of SEA(original). For the use of the alternative He line, both SEA*(original) and SEA*(modified) give lower O density than the SEA models, indicating that considering the 728.1-nm He line leads to lower density. However, it should be noted that the results from all the SEA models are within the error of the TALIF results. Moreover, the uncertainty of the SEA methods is about 20%, making it hard to define which method is more accurate in determining O density.

The mean electron energy results are shown in fig 2. It is found that the mean electron energy from SEA(modified) and SEA*(modified) is higher than that from SEA(original) due to the cascading emission term. However, SEA*(original) gives the opposite results which is close to the results from the modelling in [3].

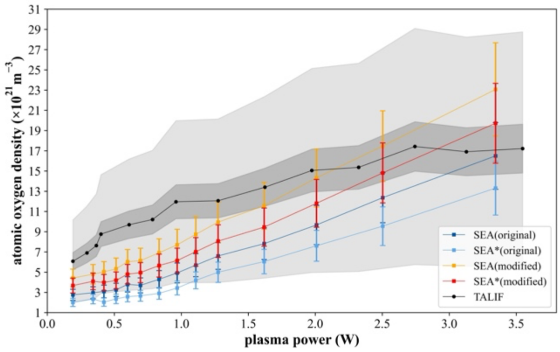


**Fig. 1.** Calculated O density from the SEA models and TALIF measurements from literature [2].

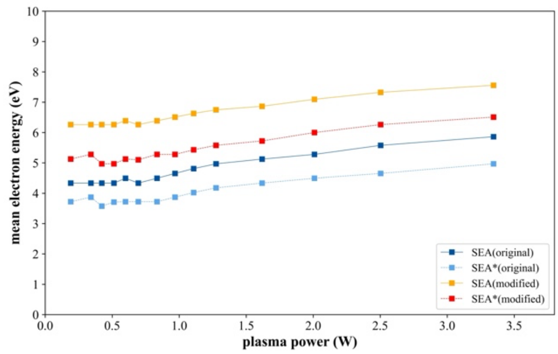


**Fig. 2.** Calculated mean electron energy from the SEA models.

## 4. Conclusion

Modifying the SEA method does change the calculated O density and mean electron energy. However, due to the lack of accurate O density, it is impossible to establish the most accurate method. The uncertainties in any of the SEA methods are approximately 20%.

## Acknowledgement

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## References

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[3] J. Waskoenig et al., PSST., **19**, 045018 (2010)