TRANSFORMING THE ENERGY LANDSCAPE FOR All

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Investigation of crystalline silicon photovoltaic modules degradation after 14 years outdoor exposure in Cologne climate (Germany) by electroluminescence (EL) and infrared (IR)

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Subject

- ❑Introduction
- ❑PV system installed
- ❑Material and method
- ❑Results and discussion
- ❑ Conclusion

INTRODUCTION

- The analysis of data collected in the field provides information on the performance of photovoltaic modules and to understand the processes leading to the damage

- To ensure the long-term reliability of PV modules, quality assurance is essential to maximise financial and energy expense

- For the reason, technical inspection methods, such as I-V curve, electroluminescence (EL) imaging and infrared (IR) thermography are applied in order to assess the quality and performance of PV modules on site (Berardone et al., 2018)

INTRODUCTION

- EL and IR are the most widely used monitoring techniques for quality control of PV modules

- The aim of this study is to investigate a photovoltaic module degradation after 14 years of exposure with electroluminescence (EL), infrared (IR) and I-V curve measurements

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PV System installed in Cologne (Germany)

Ten PV modules have been investigated at TH-Köln (Cologne University of Applied Sciences, Cologne Institute of Renewable Energy) (Germany), they are installed on the roof of the solar laboratory (see **fig.1**).

Fig.1. PV system in CIRE (Cologne)

Characteristics	Détails
Type of module	Multicrystalline
Maximum power	150Wp (±5%)
Maximum Power Point voltage	33,4V
Maximum Power Point current	4,49A
Short circuit current	4,97A
Open circuit voltage	42,2V

Table 1: Electrical characteristics of the multicrystalline silicon modules as indicated by the manufacturer

Material and method

- All the modules were exposed to field conditions in temperate climate conditions in Cologne (Germany)

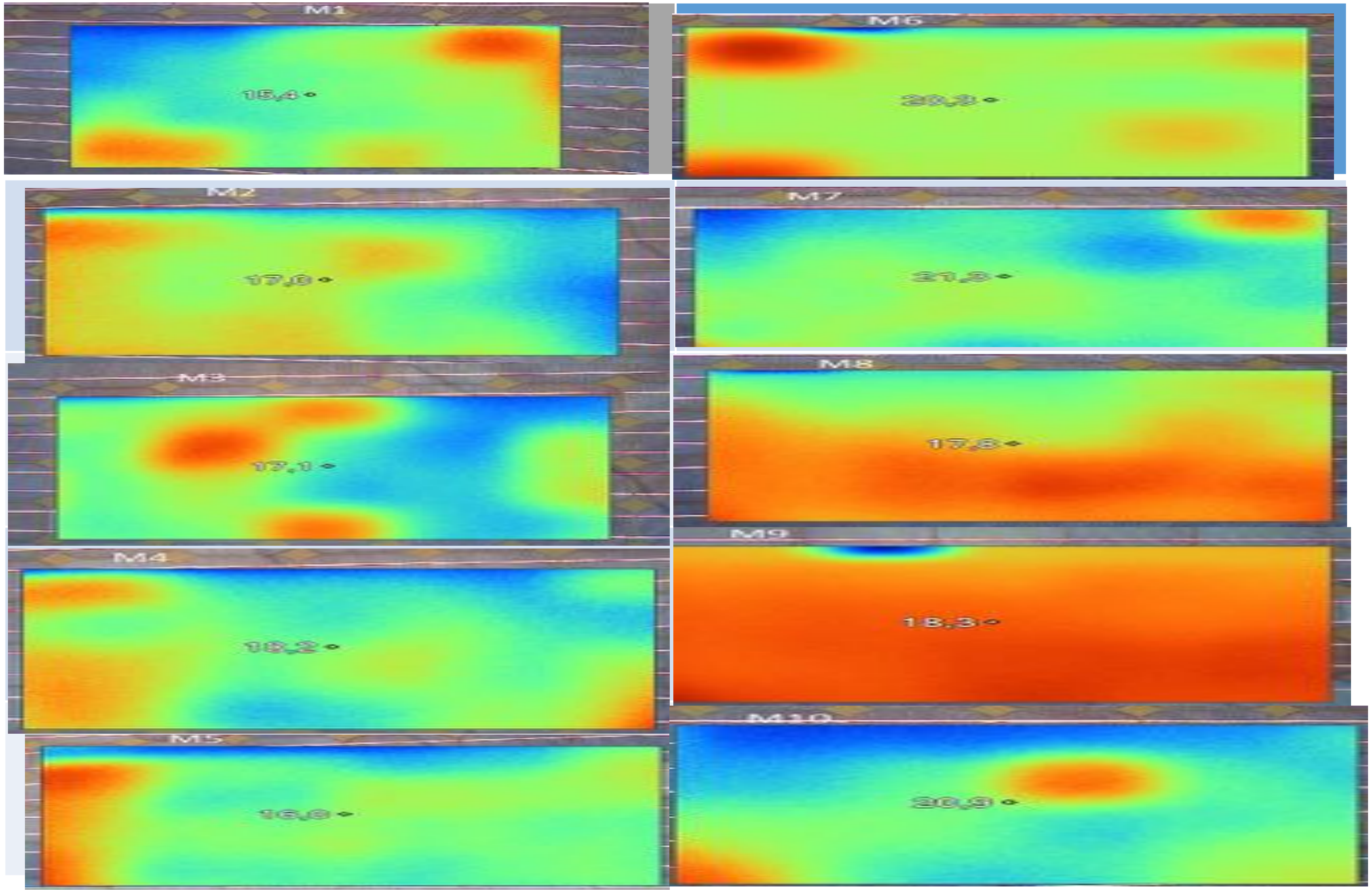
- I-V and P-V measurement are being measured at $1000W/m^2$ and at real operating conditions. We waited for a moment when the real irradiation was at least $1000w/m^2$ to take the measurements

- The modules were characterized and analysed by EL and infrared imaging technique.

Results and discussion

Thermography imaging

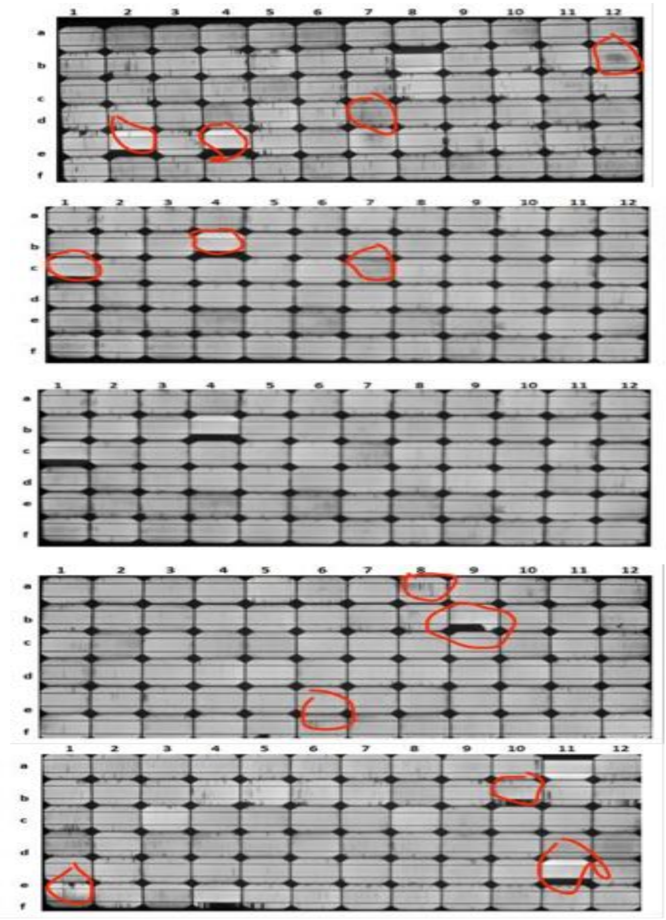
Fig.2. thermography of the ten multicrystalline PV module



The thermography imaging shows that, the modules do not have homogeneously the same temperature on the front side. Hot spots are found on the module M6; M7 and M9. **(see fig. 2).**

Results and discussion

Electroluminescence imaging



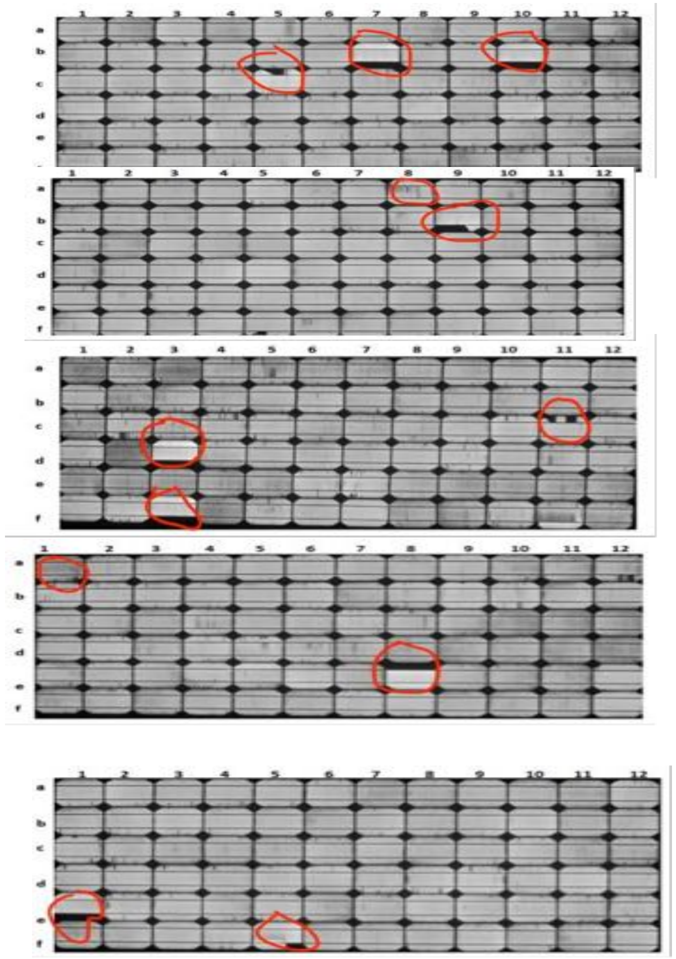
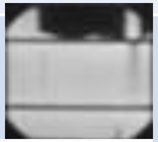
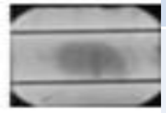
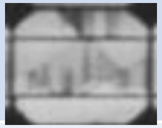
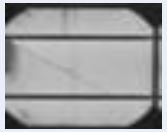
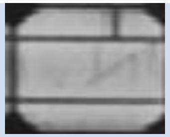


Fig 2: Different categories of defects found in different modules investigated

Name	Module		Module/cell
Finger interruptions	M8		M8 (1b)
Degradation of cell interconnection	M6		M6(2d)
Humidity corrosion in low damaged solar cell	M1 ; M2 ; M6		M1 (2f) ; M2 (8b) ; M6 (3f)
Striation ring	M2		M2 (12b)
Dendritic crack	N4		M4 (5e)
-45° crack	M1 ; M3 ; M7 ; M9		M1 (10b) ; M3 (9a) ; M7 (3e, 7e and 12e) ; M9 (3e and 12e)
+45° crack	M1; M7 ; M9		M1 (2e) ; M7 (7e) M9 (7e)

Characteristics I-V and P-V: Degradation of performance parameters

Table 3: Degradation **of** different performance parameters

Module N°	ΔI_{sc}%	ΔV_{oc}%	ΔP_{max}%	DRP_{max}%/year	DRI_{sc}%/year	DRFF%/year
1	6,46	11,12	31,02	2,21	0,46	0,036
2	6,23	11,78	29,44	2,10	0,44	0,035
3	5,83	11,42	29,67	2,11	0,41	0,035
4	5,81	11,42	30,32	2,16	0,41	0,035
5	3,82	10,94	28,39	2,02	0,27	0,036
6	5,43	11,58	30,03	2,14	0,38	0,035
7	3.82	11,09	25.94	1,85	0,27	0,037
8	3,62	11,91	27,64	1,97	0,26	0,036
9	1,20	10,75	26,46	1,89	0,08	0,037
10	3,01	11,09	27,70	1,97	0,21	0,036

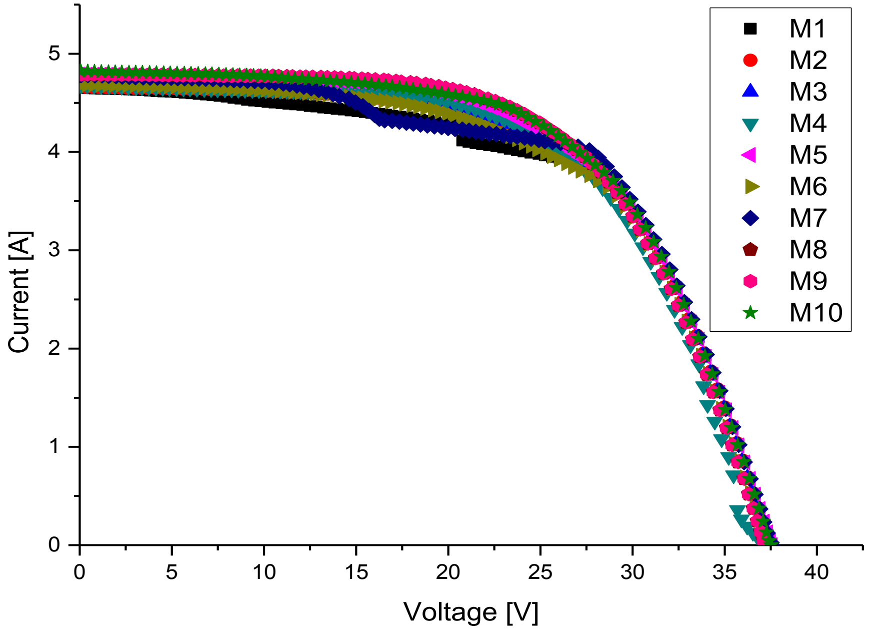
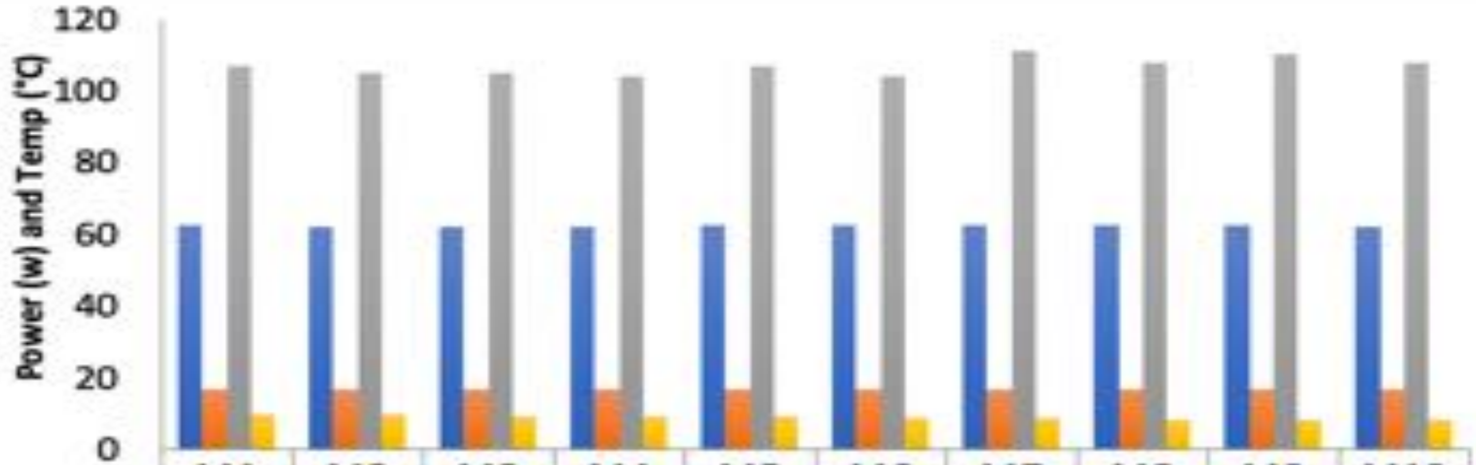


Fig.6. I-V Characteristic of the modules after 14 years

Powers (Pmax) and temperature dependance



	M1	M2	M3	M4	M5	M6	M7	M8	M9	M10
Temp, hig irr	62,64	62,12	62,24	62,29	62,71	62,73	62,77	62,4	62,59	62,02
Temp,low,irr	17,04	17,03	16,99	16,97	16,94	16,91	16,89	16,82	16,78	16,77
Power high	107	105	105	104	107	104	111	108	110	108
Power low	9,62	9,55	9,39	9,26	9,52	8,68	8,68	8,54	8,58	8,27

CONCLUSION

- ❑This work proposes a characterization of crystalline PV modules after 14 years in outdoor exposure at Cologne (Germany).

- ❑ The principal method is Electroluminescence (EL), infrared imaging (IR), I-V and P-V characteristics.

- ❑ Results show that the maximum power degradation rate and the maximum short circuit-current degradation rate are 2,21% per year and 0,46% per year, respectively

THANK YOU！