



Overview of Thales Cathode technology and new developments.

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THALES – May 2020





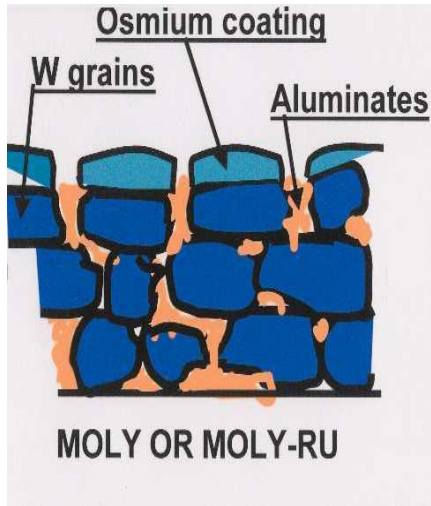
Outline:

- Introduction
- Types of Cathodes at Thales
- History of the Cathodes at Thales
- Testing and Characterisation of Cathodes at Thales
- New developments
- Conclusion

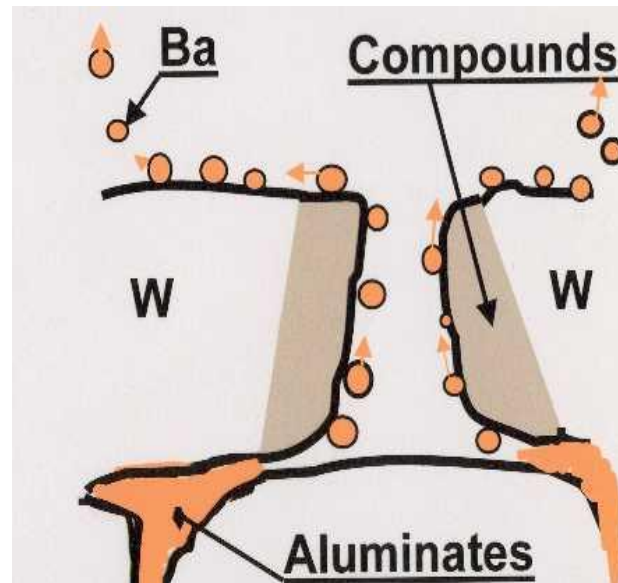
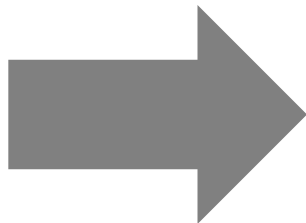
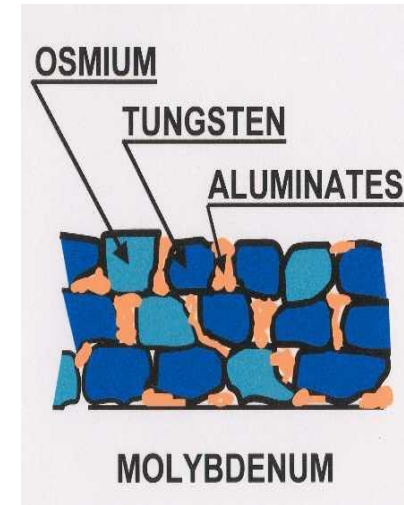
Types of Cathodes used at Thales



M-type Cathode



MM-type Cathode



Common Principle:

- thermal activated diffusion process
 - > Ba transport to surface
- generation of Ba monolayer

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MM Cathode History in Ulm

1970/1974 pure tungsten matrix

MIL / SAT

current density $>1\text{A/cm}^2$

cathode temperature $T_k=1020^\circ\text{Cb}$

life expectancy 7-10 year

1982 W/Ir and W/Os mixed metal matrix

MIL

current density $j < 4\text{A/cm}^2$

cathode temperature $T_k=1020-1100^\circ\text{Cb}$

1985 W/Os mixed metal matrix

SAT

current density $j < 2\text{A/cm}^2$

cathode temperature $980-1040^\circ\text{C}$

life expectancy 15 years

1990 Improved W/Os mixed metal matrix

SAT

current density $j < 2\text{A/cm}^2$

cathode temperature $980-1020^\circ\text{Cb}$

life expectancy: 20y

M-Cathode History in Velizy

1973 S-type cathode

MIL / SAT

cathode temperature $T_k=1035^\circ\text{Cb}$

life expectancy 7-10 year

1982 M-type cathode

SAT (Intelsat 6)

current density $j < 2.5\text{A/cm}^2$

cathode temperature $T_k=985^\circ\text{Cb}$

life expectancy $>15\text{y}$

In Orbit Experience from 1972 to Sep 2019

Freq. Band	Cooling	Delivered TWTs (not yet launched)	TWTs in Orbit	
			Qty (1)	K. Hours (2)
S / L	CC	355	644	33,686
	RC	13	91	1,619
C	CC	564	3,609	219,595
X	CC	298	467	20,771
X	RC	0	25	220
Ku < 80 W	CC	87	1,674	132,569
Ku > 80 W	CC	340	3,699	235,148
	RC	723	5,883	319,384
Ka < 80 W	CC	360	993	49,568
80W< Ka <140 w	CC	306	1,394	52,352
80W< Ka <140 w	RC	677	1,559	50,969
140W< Ka <170 w	CC	217	0	0
140W< Ka <170 w	RC	17	0	0
Q-Band	CC	15	0	0
pulsed	CC	4	28	1,274
		3,976	20,066	1,117,155
		24,042		

Total delivered TWTs (at customer):	3,976
Total TWTs In-Orbit:	20,066
Total In-Orbit Operating Time (h):	1,117,155,017

Note 1 : Including redundant TWTs

Note 2 : Excluding redundant TWTs. Redundancy of 66% is assumed, if redundancy scheme is unknown

Note 3 : Launch dates as per Airclaims SpaceTrak CD-Rom



Cathode Pellet Characterisation

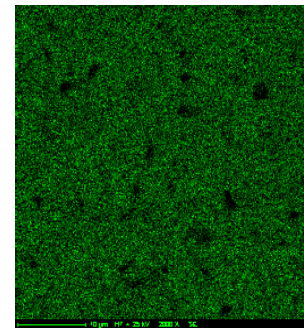
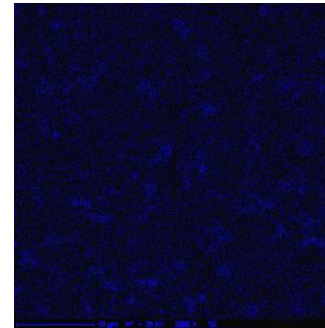
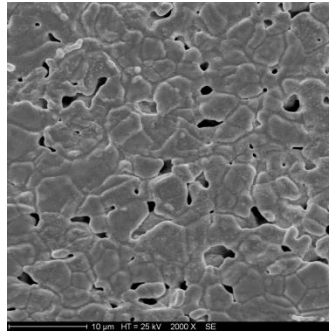
For each cathode batch, the pellet is checked concerning its porosity, for this, a cross cut section is prepared and analysed with optical microscope, SEM and EDX. The chemical surface composition is checked via Auger.

SEM

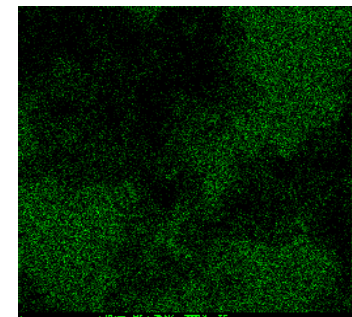
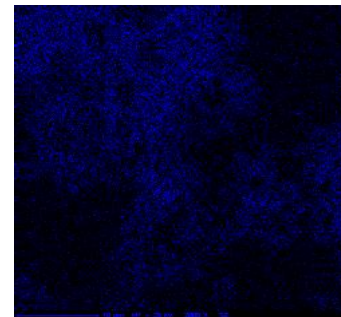
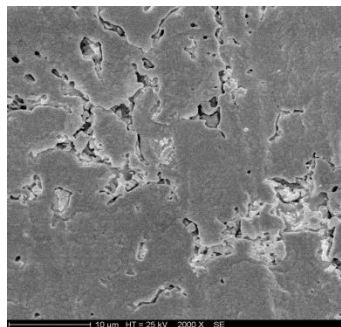
EDX-W

EDX-Os

M-Type



MM-Type



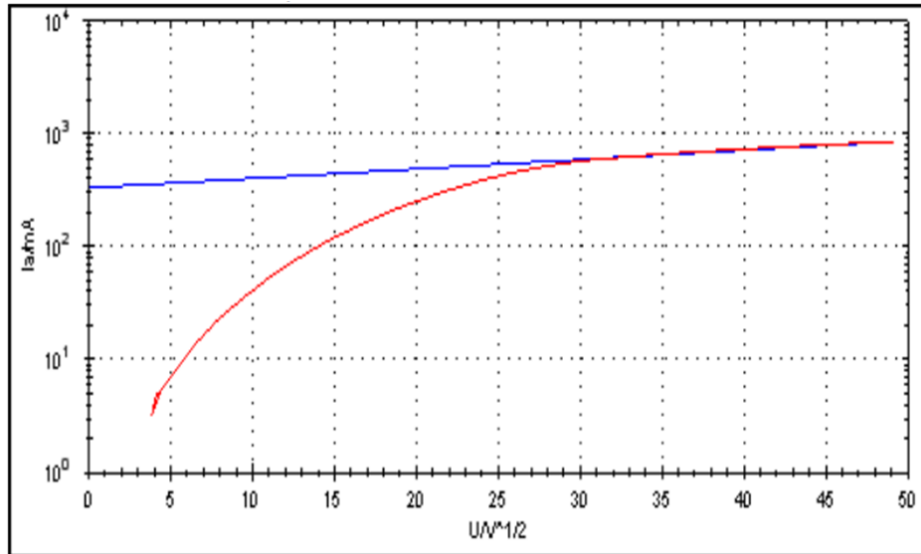


J0 measurement

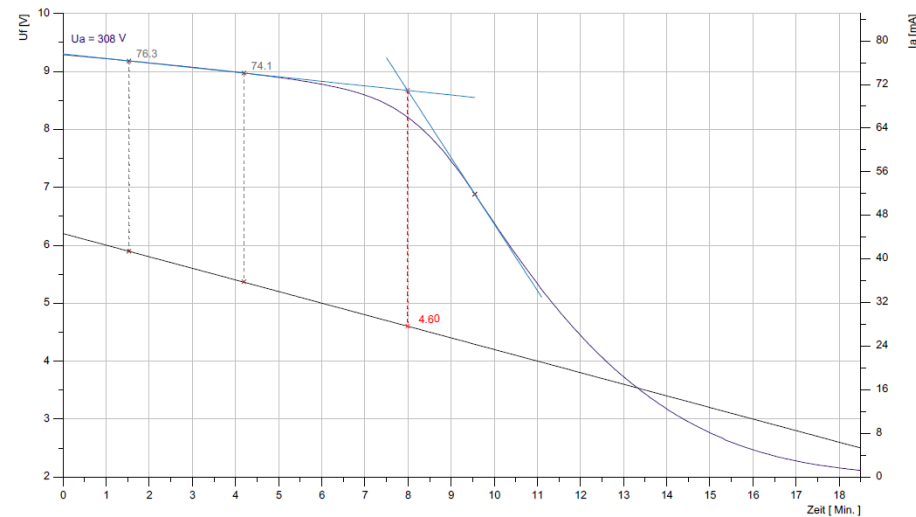
In order to have information about the effective work function and to have a process control, J0 measurements are performed.

Miram plot (underheating curve)

The knee point temperature and the corresponding heater power is determined by a miram plot (underheating curve)



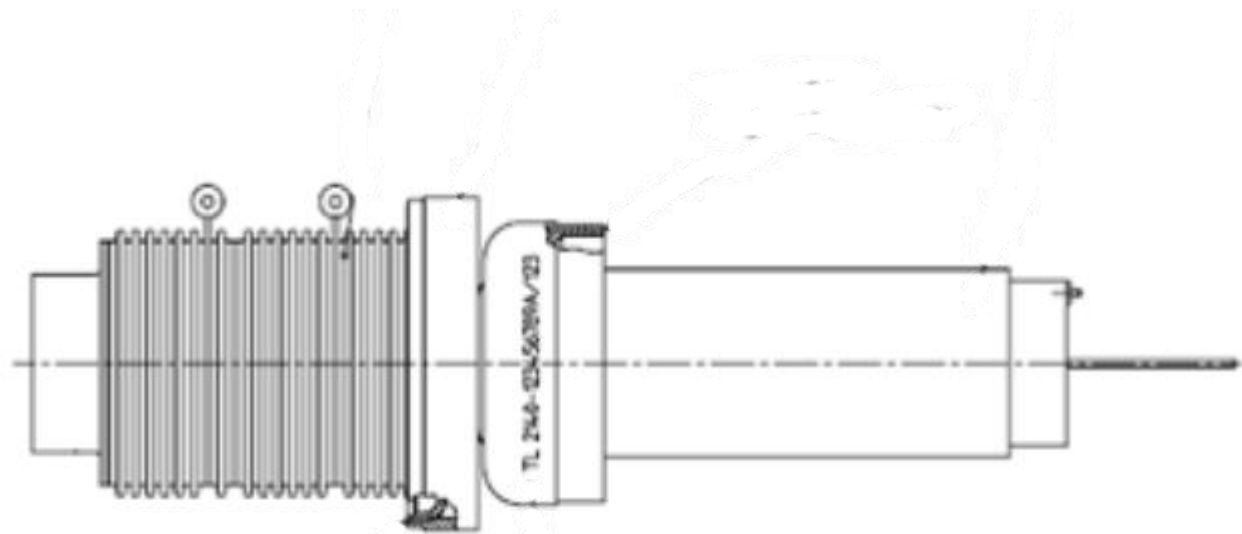
Emission current density 4,95A/cm² // $\Phi=1,99\text{eV}$





life test vehicles

The life test vehicles are designed in order to have a realistic and representative environment for the cathode as possible. For tubes they consist of an electron gun as it is used in a TWT together with a simplified one stage collector. If temperature measurements are needed the life test vehicles are equipped with a window to access the cathode temperature with an pyrometer.

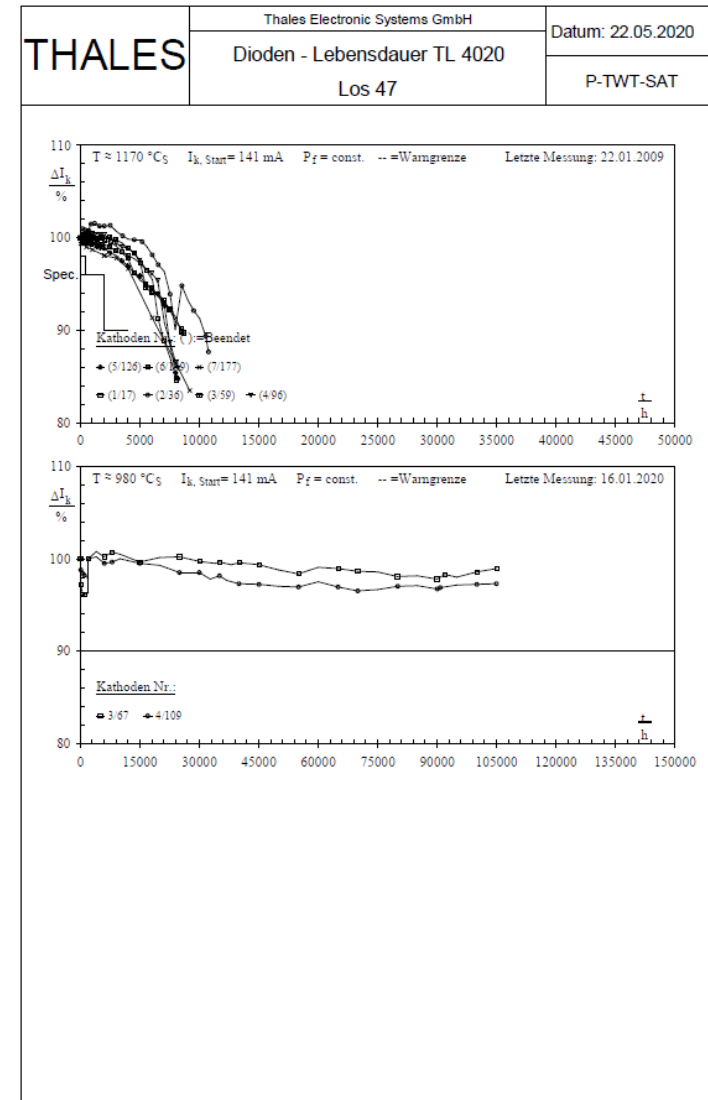
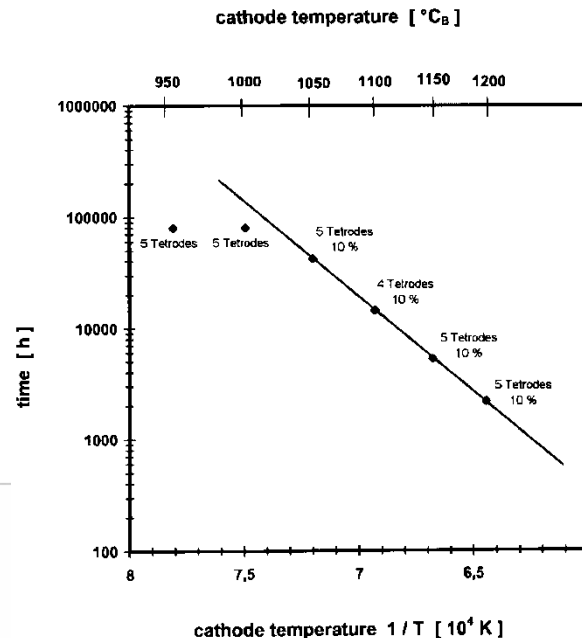
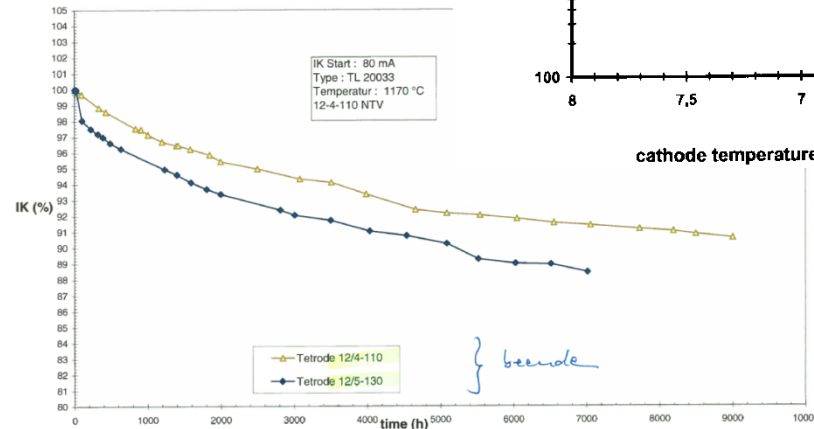


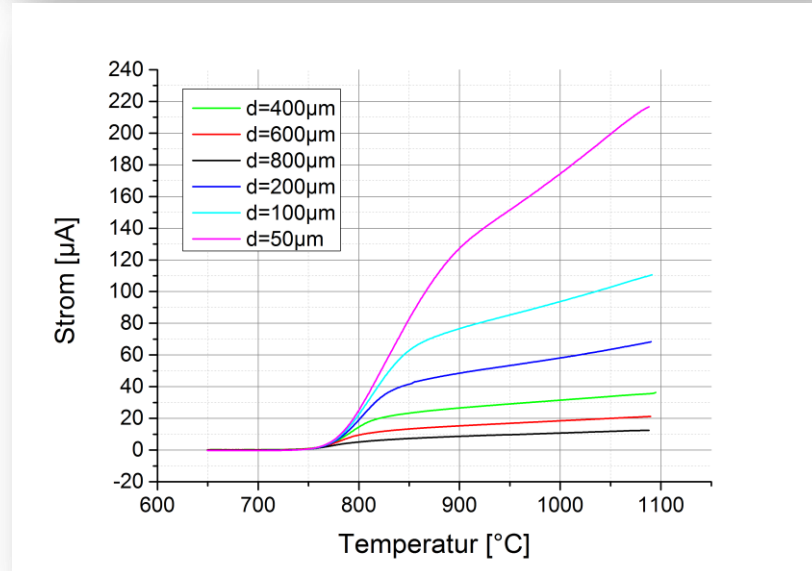
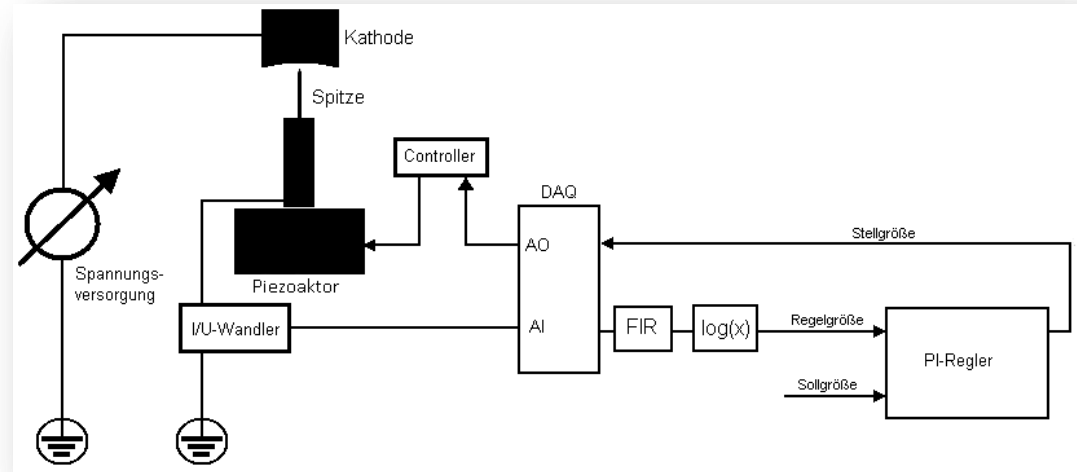
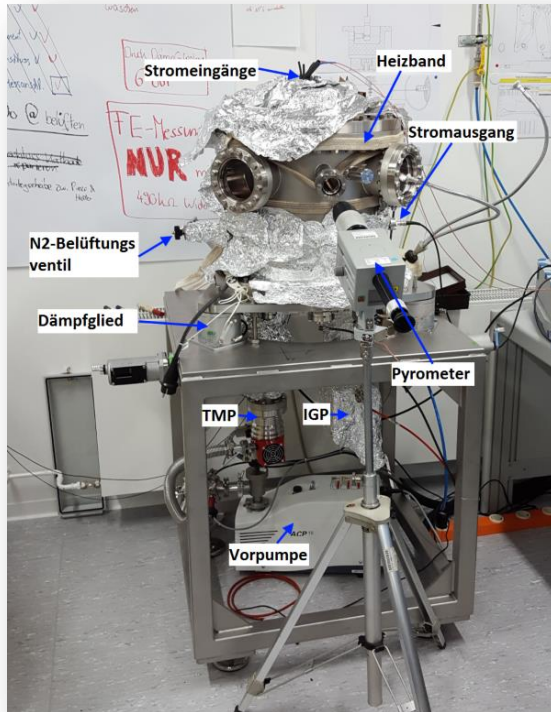
life test vehicle for cathodes



As the acceleration factor is well known,
Lifetests at operating temperature and accelerated
Lifetests are performed for each Lot.

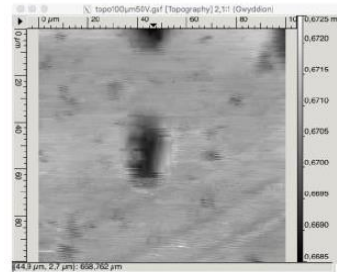
The results are
reviewed on a regular
basis



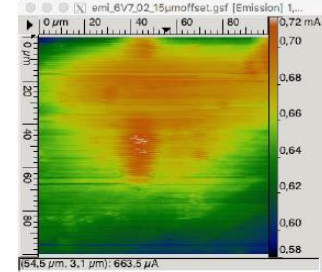




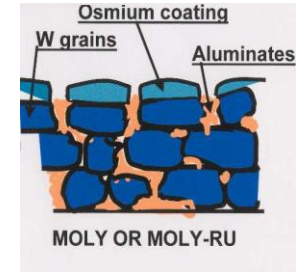
M-Cathode



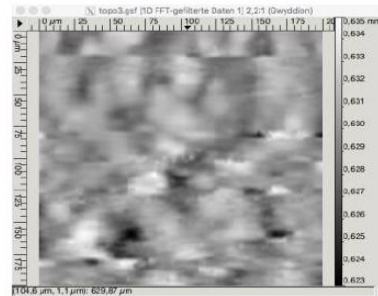
Topography 100μm x 100μm
single Pore in the Middle of
image



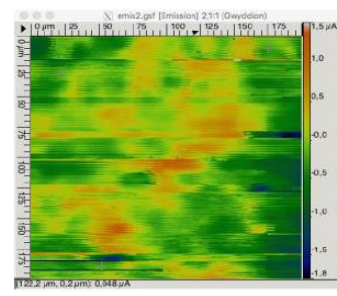
Emission image



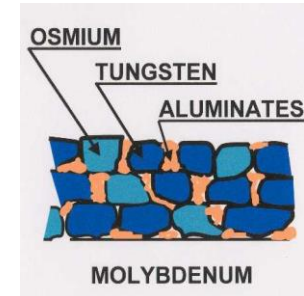
MM-Cathode



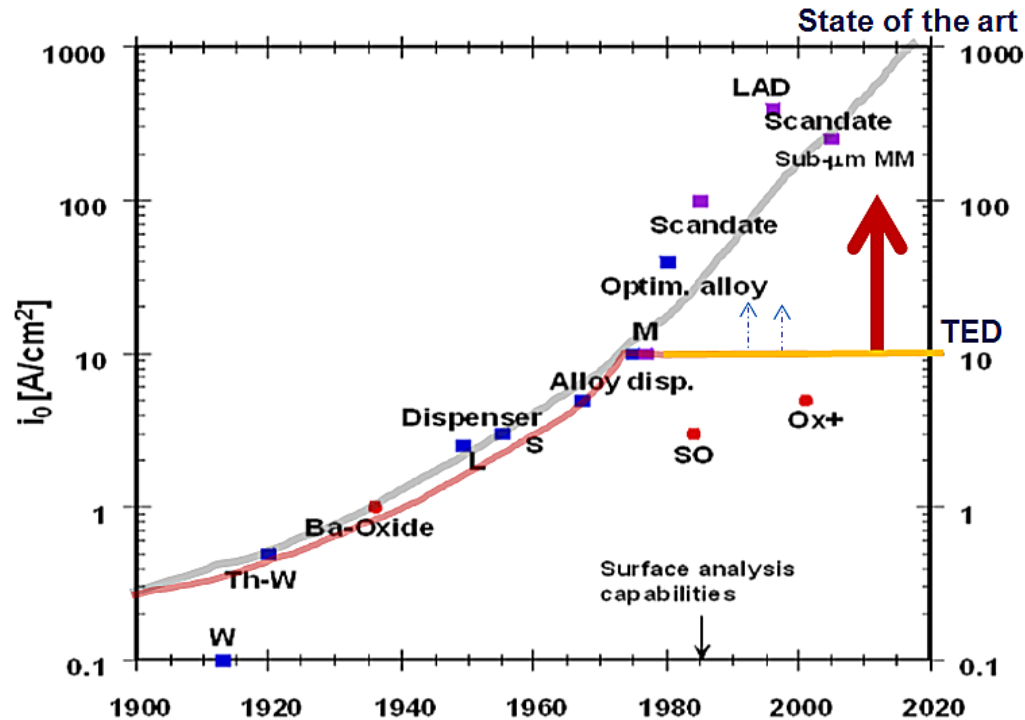
Surface of a Cr Cathode treated
with EDTA. Area is 200μm x
200μm.



Emission image of the surface
on the left.



physical effects and mechanisms can be investigated on the sub μm scale
this will give new insights on the mechanisms of thermionic emission and
the ageing behaviour.

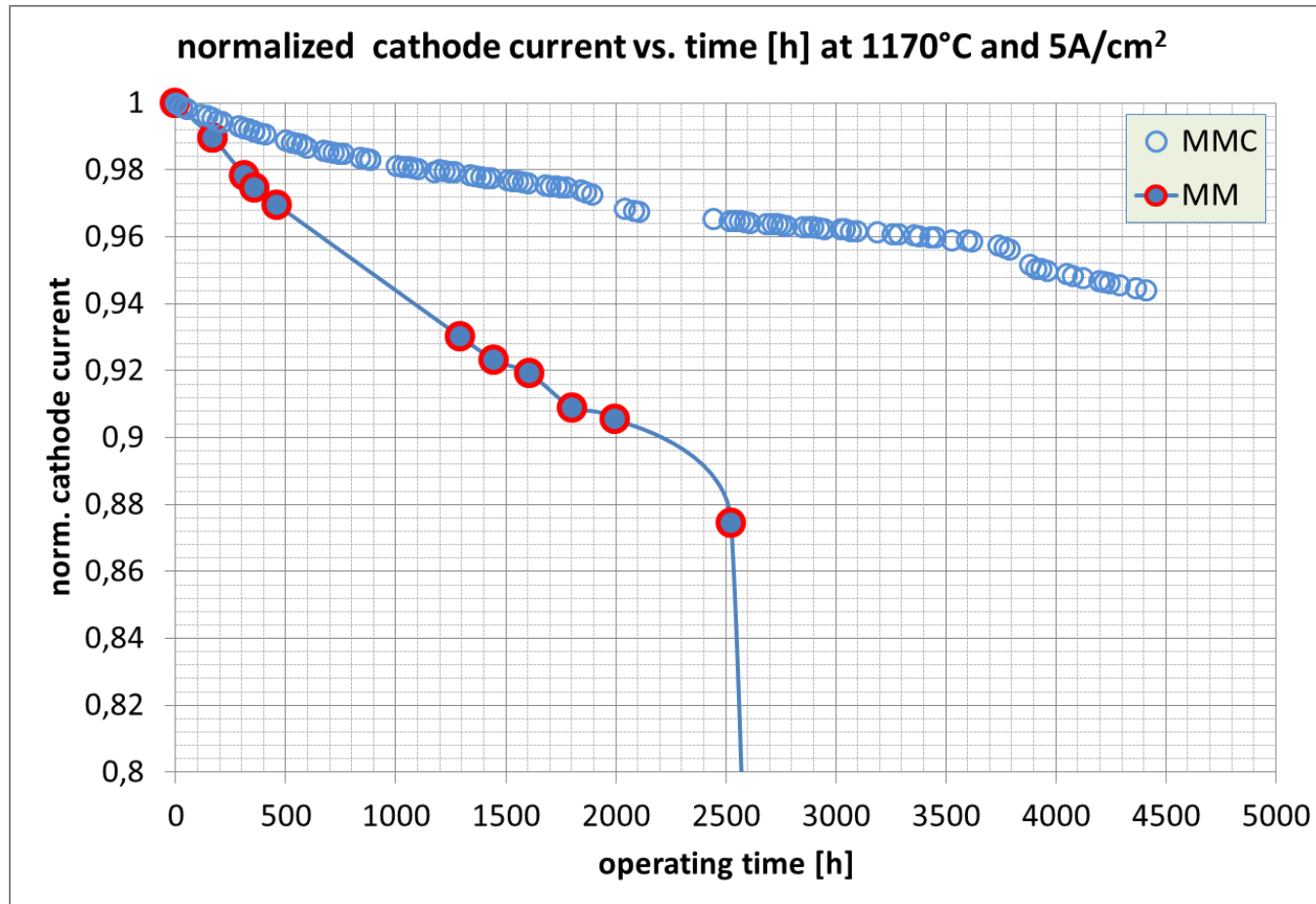


Thales is working on several new technologies in order to increase the current density and to prolong the lifetime of Cathodes.

- MMC Cathodes: 5A/cm² for 15 years -> qualification ongoing
- Scandates: >10A/cm² -> first experiments
- Qualification of M-type cathode with 4 A/cm² (talk of J. Demory)



Example MMC Cathode





- Types of cathodes at Thales
- Characterisation of cathodes
- New way for characterisation
- New developments

The work presented is supported by DLR and ESA.

Thank you for your attention