# Cathodes

TMD Technologies Limited (formerly Thorn Microwave Devices Ltd) is recognised as a UK Centre of Excellence for dispenser cathode technology.

For over 20 years TMD has been funded by a number of organisations, including the UK MoD and ESA, to investigate the fundamental chemical and physical properties of impregnated tungsten dispenser cathodes. This work has resulted in:

- Cathode coatings providing over three times the emission current densities previously available, with:
  - lower cathode operating temperature
  - reduced impregnate depletion
  - longer cathode life
- Improved processing and assessment techniques to optimise quality, consistency and reliability.

Originally developing cathode-manufacturing skills in support of its microwave tube business, the company now offers cathodes to a wide variety of other industries encompassing scientific, laboratory and medical applications.

## CATHODE EMISSION OPERATING RANGE

Please also see the Cathode Emission Data diagram

| Type | Emission ($A/cm^2$) @ 1030 °C brightness |
|---|---|
| B | ≤ 3 |
| M | ≤ 8 |
| CD50 | ≤ 15 |

Operating environment: vacuum better than $10^{-7}$ mbar

## MANUFACTURING CAPABILITY

TMD's resources for manufacturing its range of dispenser cathodes include:

- workshop facilities with considerable experience in precision machining of porous tungsten and molybdenum
- hydrogen furnaces for brazing and cathode impregnation
- laser and spot welders
- RF sputtering systems for cathode coating

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## QUALITY ASSURANCE

Cathode quality is maintained by rigorous inspection of piece parts and sub-assemblies. Additionally, test cathodes are produced alongside production devices and emission tested at key process stages. Routine surface analysis is carried out on cathodes using a custom built auger electron spectrometer (AES) system, The system is capable of analysing cathodes at their operating temperature (> 1000 °C) to ensure the absence of life and performance reducing contaminants.

## THE DISPENSER CATHODE

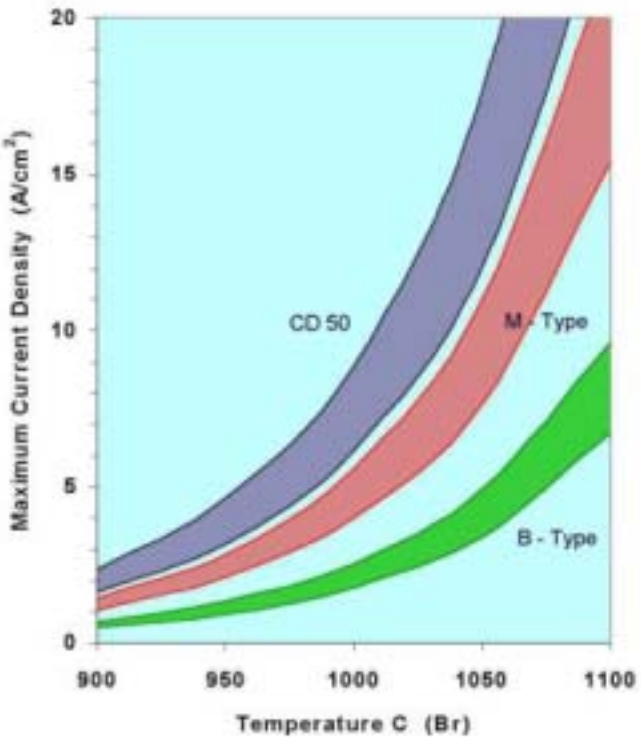
Cathode Schematic

B-type

The basis for the present day dispenser cathode is the Phillips B-type cathode developed by Levi in 1953. The device consists of a porous tungsten button impregnated with an emissive mix of barium, calcium and aluminium oxides. At operating temperatures in excess of 1000 °C the impregnant reacts with the tungsten matrix to produce free barium, which migrates to the cathode surface. Whilst part of the barium evaporates from the cathode, some of it spreads over the porous tungsten surface where, in conjuction with residual oxygen, it lowers the work function from c. 4.5 eV to 2.1 eV. Emission levels in the 2 - 3 A/cm$^2$ are possible with operating life expectancy in the tens of thousands of hours.

## Coated Cathodes

A significant increase in emission level is obtained when the emitting surface of B-type cathodes is coated with a higher work function metal such as osmium, ruthenium or iridium, or with mixed alloys of these metals and tungsten. TMD produces two coated cathode formats, the M-type and CD50 with osmium and osmium/tungsten alloy coatings respectively.




Compared to the basic B-type device, the lower work function surfaces produced by the coatings enable these cathodes to operate at higher emission levels at a fixed temperature, or longer life at a fixed emission level.

## Emission Data

Maximum recommended current density as a function of temperature.

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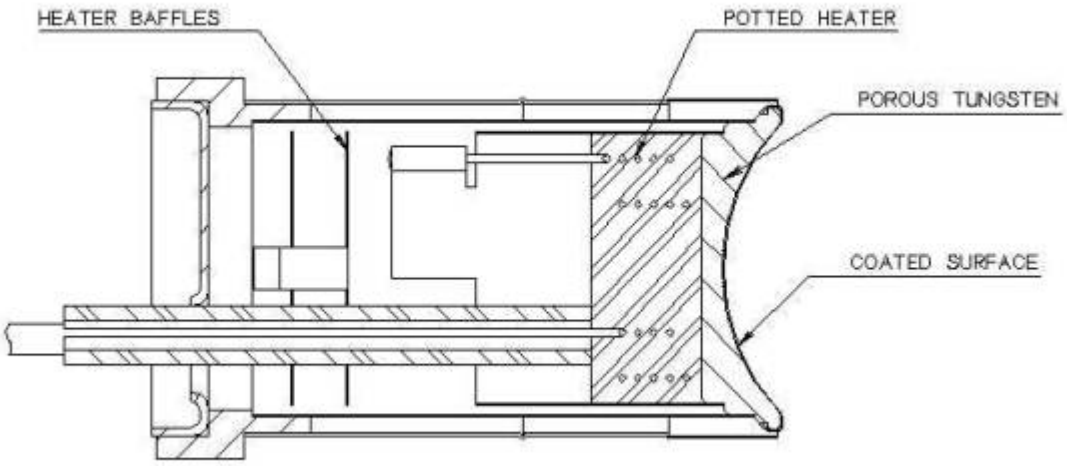
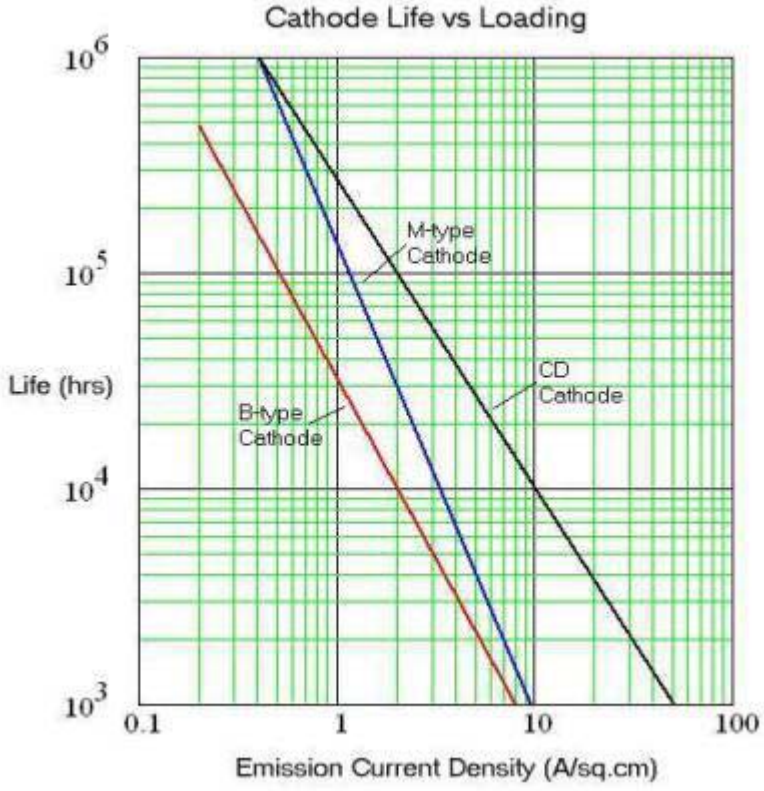
## Cathode Schematic




## Cathode Life as a function of Cathode Loading

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**UHV system used for auger surface analysis and emission testing.**

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**Cathode undergoing surface analysis at operating temperature in Auger system.**

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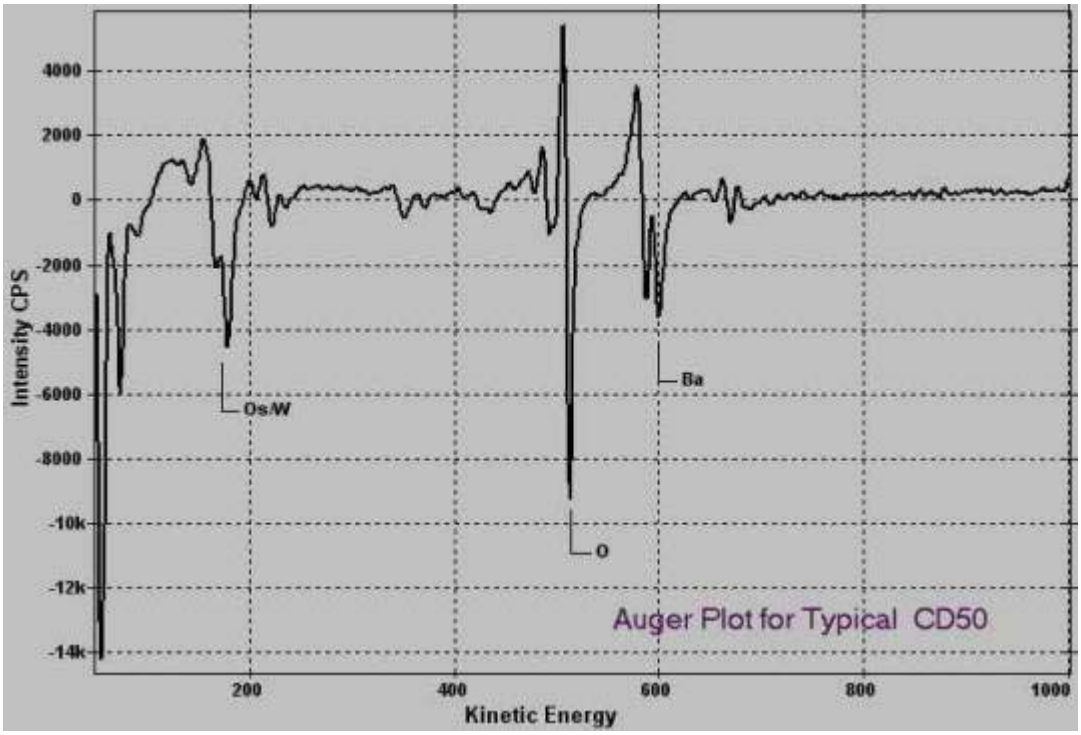
**Auger Plot for Typical CD Cathode Surface**

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