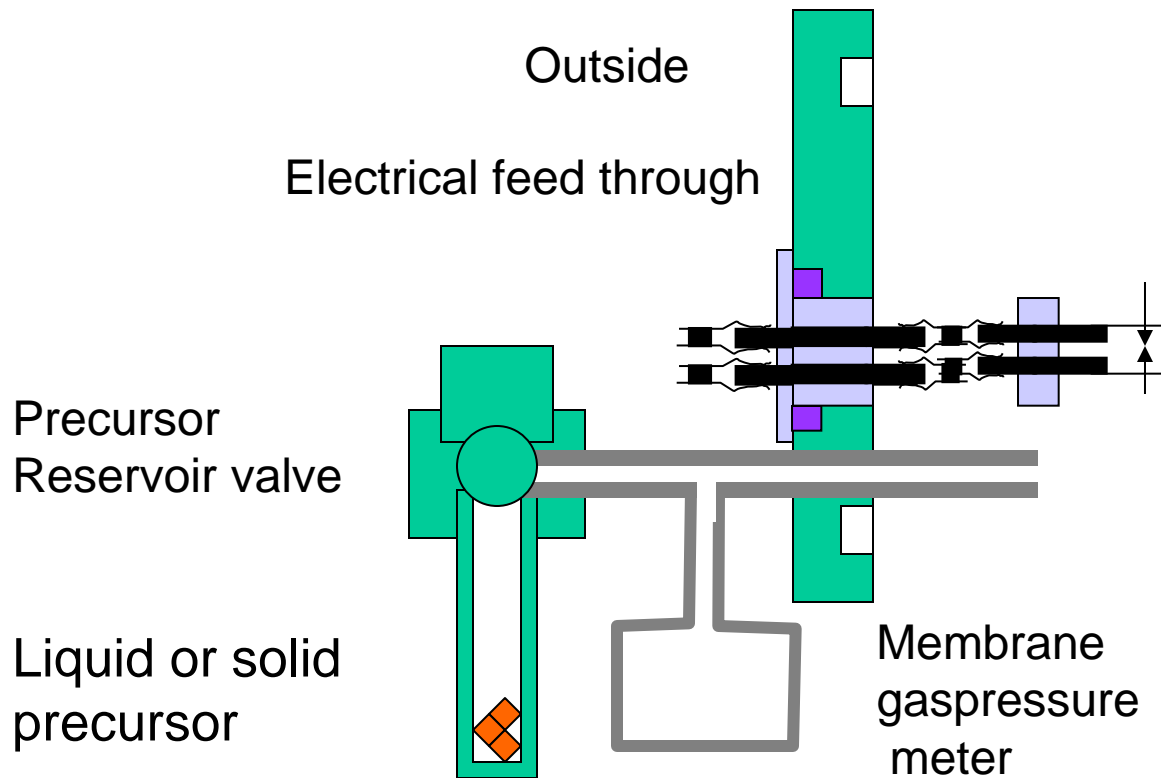


High field induced tip growth experiment

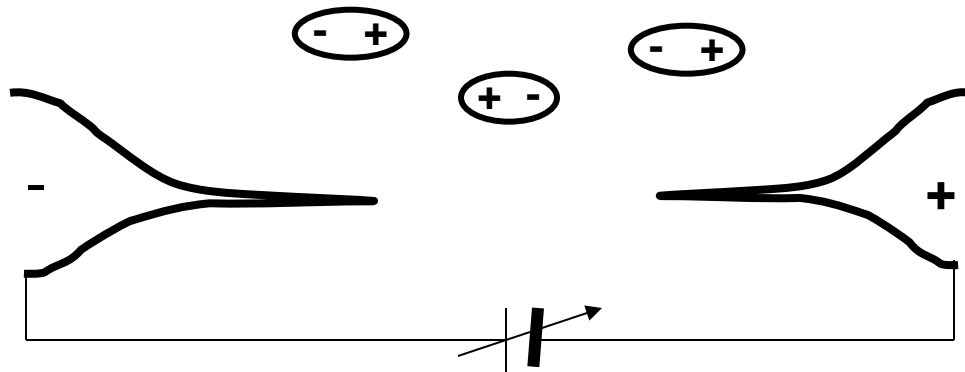
Drawing schematic, not to scale




Etched tips mounted
with silver paint
in < 1 mm distance

**Bischoff approached
his tips to 100 nm
and grew a carbon
wire from Acetone and
pump oil vapour**

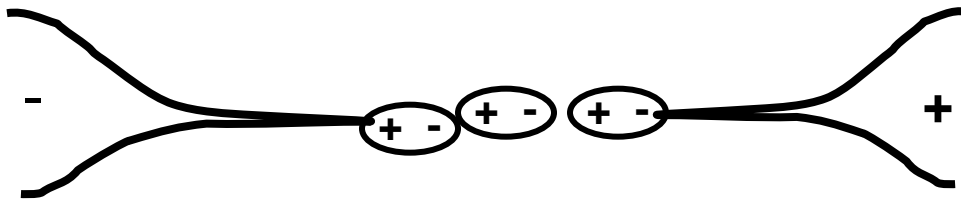
High field growth mechanism



2 Tips in 100 nm distance

 Acetone or polarized oil molecule in the vacuum

High field gradients move dipoles and attract them to the top of the tip



Finally the wire closes the gap and a current starts to flow

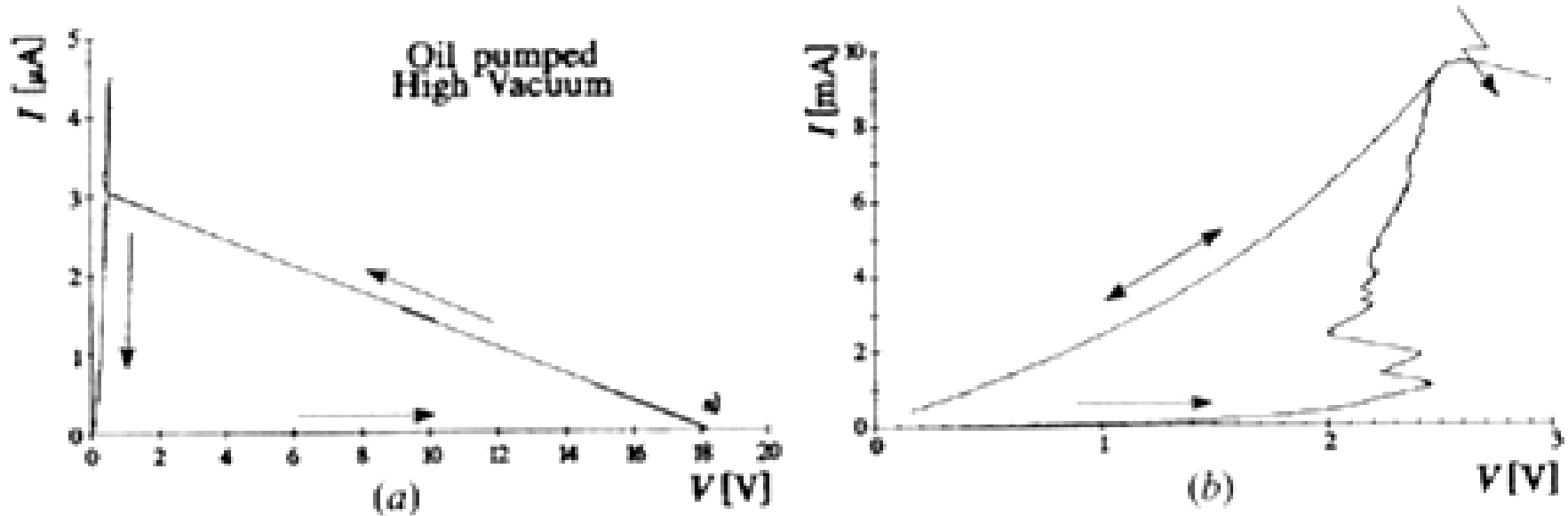
The wire pyrolyzes by heating and carbonizes.

An I/V curve can be measured.

Above 2.7 V the wire evaporates and forms a plasma and the current stops

Procedure for reproducible forming of a supertip in high electric fields

(M. Bischoff Int. Journal of Electronics 1992, Vol. 73 No.5, 827-828)



Filament generation and forming between 100 nm separated tips: (a) I - V characteristic of the initial generation of conductivity; and (b) I - V characteristic showing the irreversible increase of conductivity of an existing path between the carbon tips. When 2.7 V is reached the path is destroyed.

Accordingly to this growth in high electric field it is possible to grow a tip with a current limited voltage supply.

Since all tips grow in the same way a large number of tips can be grown on individual protrusions with a similar result: tip radius, length, emission current

Fieldemitter tips for atom probe mass spectrometers

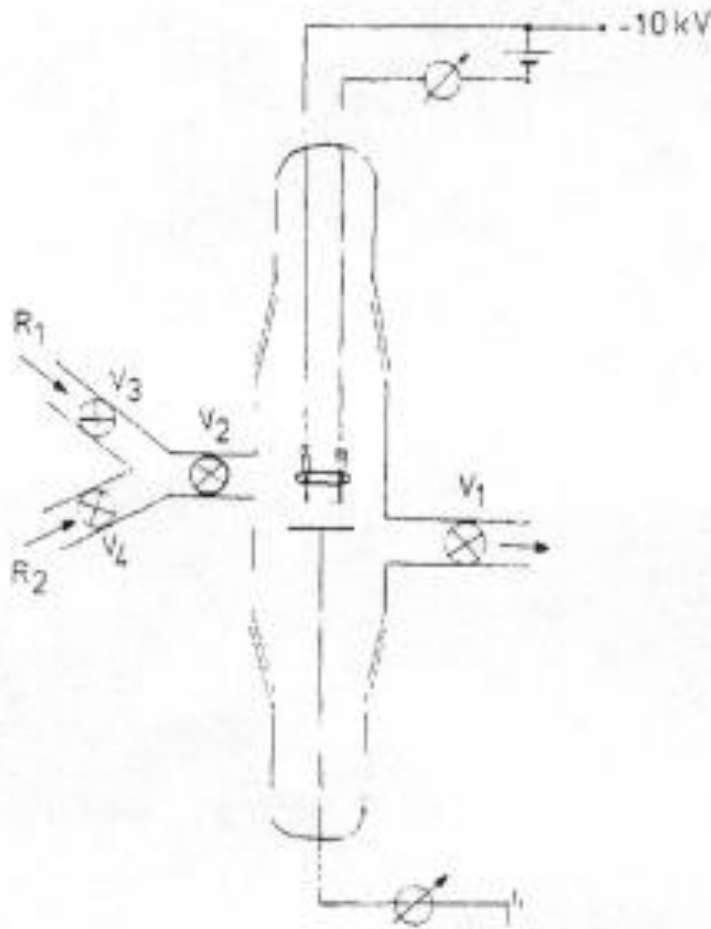
J. Phys. E: Sci. Instrum., Vol. 11, 1978. Printed in Great Britain

High-rate growth of
dendrites on thin wire
anodes for field
desorption mass
spectrometry

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Received 17 February 1978, in final form 2 June 1978

Dendrites growth on 10 μm W wire @ 10 kV



Field strength for growth : $E = U/r = 2 \cdot 10^7 \text{ V/cm}$

- @ 1 μm tip 1 kV required
- @ 0.1 μm tip 100 V
- @ 3 atom tip (100) edge 2 V required !!

The mechanism ist:

Due to the high dipole momentum of the Organic vapor: Benzonitril (4.8) or Acetone (2.9)

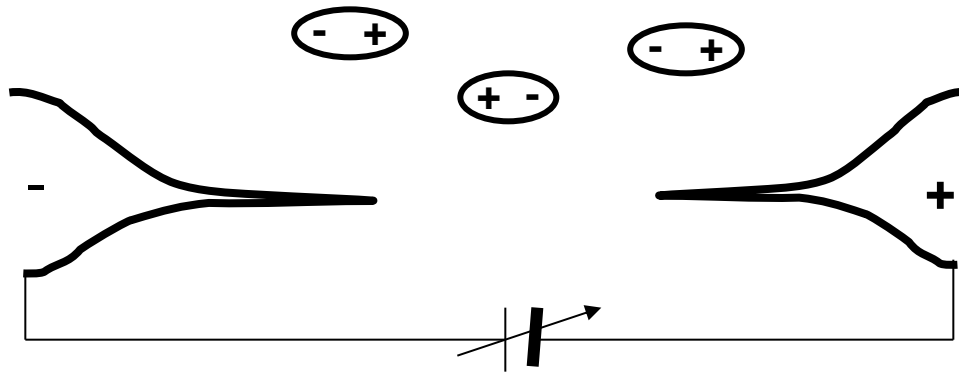
The Molecules get attracted to the tip, and field ionized and are ejected from the tip as a negative charged particle

In close vicinity of the tip $\text{W}(\text{CO})_6$ molecules Are ionized by the negative ion and are attracted to the tip by the induced dipole momentum and hit the tip and deposit there as neutral.


Figure 1 HR activation cell. R_1 , R_2 , reservoirs for benzonitrile and tungsten hexacarbonyl; V_1 - V_4 , valves. The instrument for vapour pressure measurement is not shown.

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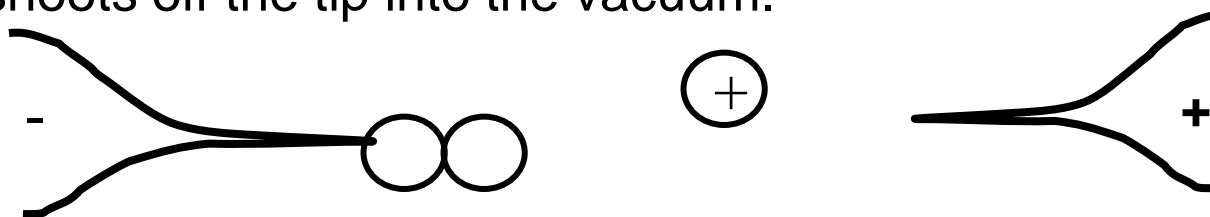
High field growth mechanism with 2 sorts of molecules




2 Tips in 100 nm distance

 Acetone or polarized oil molecule in the vacuum

High field gradients move dipoles and attract them to the top of the tip
The molecule receives one electron from the tip and becomes an ion and shoots off the tip into the vacuum.



 **W(CO)₆**
gets ionized and attracted to the tip and neutralized

A W-wire grows and finally the wire closes the gap and a current starts to flow
An I/V curve can be measured- also before the closing of the gap to render a short tip.

All tips will grow in the same way, pressure and field depending.

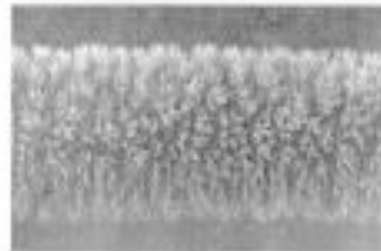
Emitter with

	Dense carbon dendrites	Single dendritic tungsten bundles	Many tungsten needles
Pressure (Pa)	Firstly 0-4 (BzCn), then 0-5-0-6 + W(CO) ₆	0-3 (W(CO) ₆)	0-3 (W(CO) ₆)
Emitter temperature (K)	≈ 1200	≈ 800	≈ 800
Emitter heating current (mA)	30-60† 40-90	40-85	40-85
Potential difference (kV)	8-10	8-10	15-20
Protective resistance (MΩ)	7-10	7-10	1-3
Electron emission current (mA)	1-2	1-2	5-8
Length of dendrites (μm)	50-60	40-50	≈ 40
Time of activation (min)	10	8-10	5-6

HR-Dendrites growth



(a)

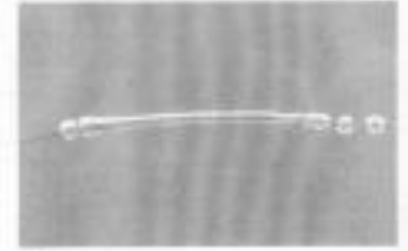


(b)

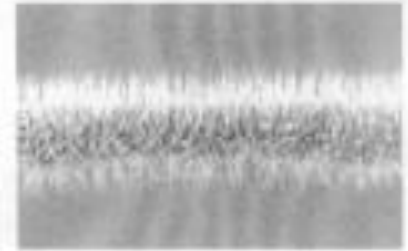


(c)

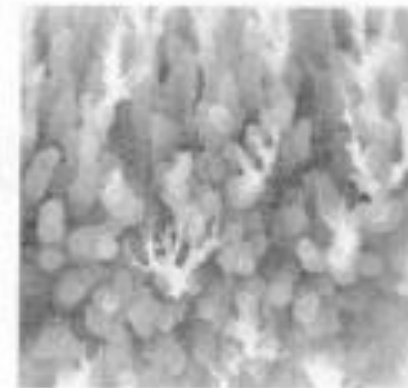
Figure 2 Scanning electron micrographs of an emitter covered with carbon needles at magnifications of (a) 13x, (b) 130x, (c) 1300x.



(a)



(b)

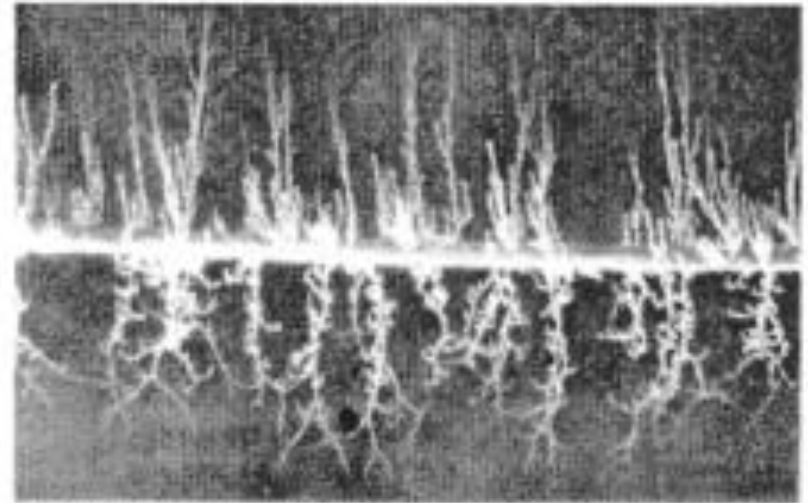
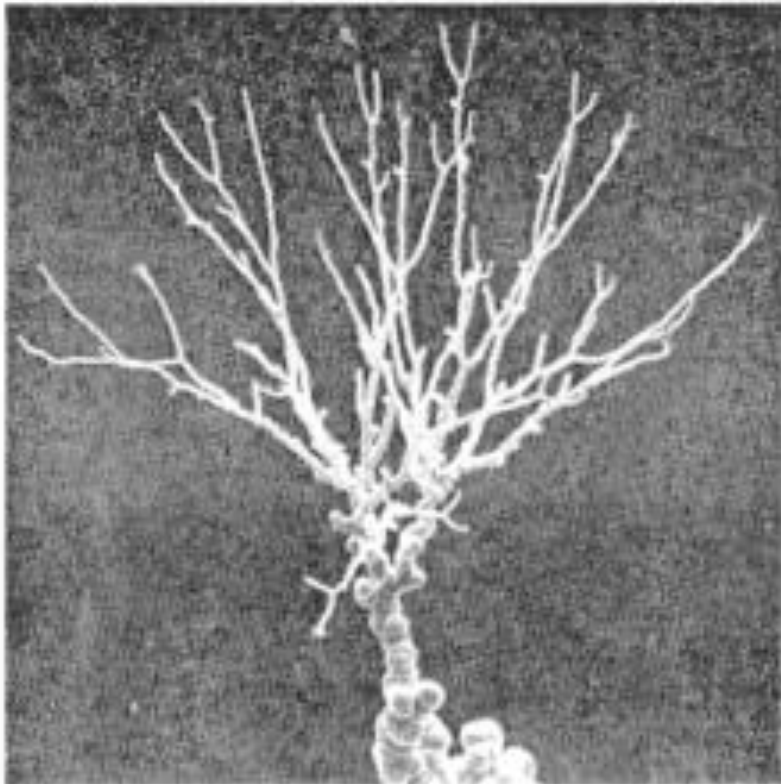


(c)

Figure 3 HR-emitter covered with carbon needles at magnifications of (a) 34x, (b) 340x, (c) 1500x.

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Hr Emitters with W dendrites



(b)

Figure 4 HR emitters with tungsten dendrites arranged in (a) a single bundle (magnification $4800\times$), (b) many bundles (magnification $230\times$).

Hr Emitters with W-Fe alloy

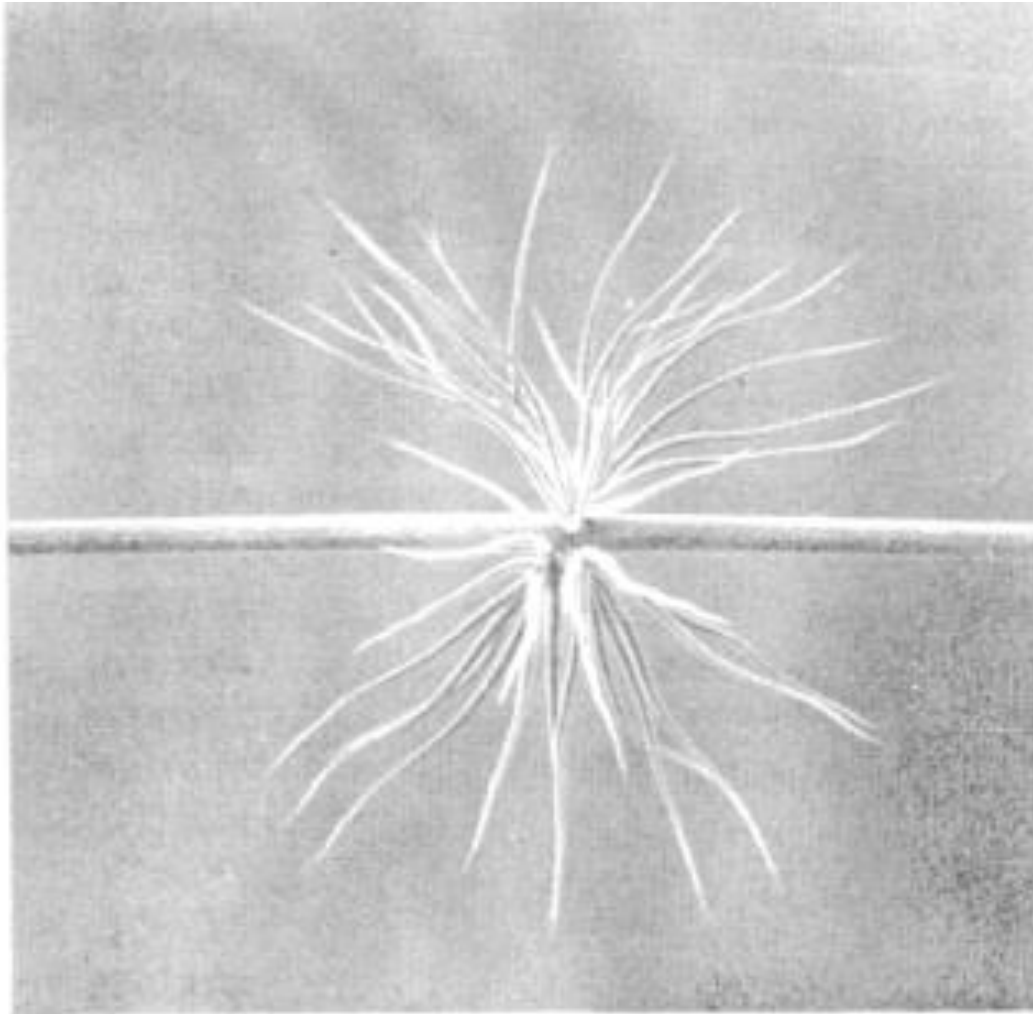


Figure 5 HR emitter with needles of a tungsten-iron alloy (magnification $230\times$).