McMaster Accelerator Laboratory, KN Accelerator

1.1 General description

The McMaster Accelerator Laboratory was commissioned in 1969 as a part of the McMaster University Physics Department. Its primary purpose was the study of Nuclear Structure Physics, however, many experiments in other disciplines were also carried out. The 1600 m^2 laboratory contained two electrostatic accelerators; a 3 MV, model KN single-ended Van de Graaff and an 11 MV FN Tandem Van de Graaff.

Funding for the FN accelerator ceased in 1997 and the FN and its associated beamlines and target chambers were shipped to Argentina. Operation of the KN accelerator continues as part of the McMaster Institute of Applied Radiation Sciences (McIARS).

Future expansion includes a second KN being installed as part of a biological microprobe laboratory and a 1.25MV Tandetron which has been purchased to supplement the current KN's experimental program. It is scheduled for delivery in spring 2003.

1.2 Use of the facility

The primary KN experimental program is study of trace metals in biological samples using low energy neutrons. The neutrons are produced by a proton beam ≤ 2.5 MeV on a lithium target or ≤ 2.5 MeV on a Be target.

Resonant γ capture studies of nitrogen concentrations have also been conducted. These 9.17 MeV gamma rays are produced by 1.7 MeV protons on a ^{13}C target in the reaction $^{13}C(p,\gamma)^{14}N$.

1.3 KN Specifications

The KN accelerator is a horizontal, belt-charged, single-ended Van de Graaff with a design rating of 3 MV. It was built in 1956 by High Voltage Engineering Corporation of Burlington, Massachusetts, U.S.A. (now High Voltage Engineering Europa B.V. Amersfoort, The Netherlands). Sulphur hexafluoride or Nitrogen/Carbon Dioxide is used as the insulating gas. The beam is generated by an r.f. ion source in the terminal. All operating parameters are controlled remotely from the control room.

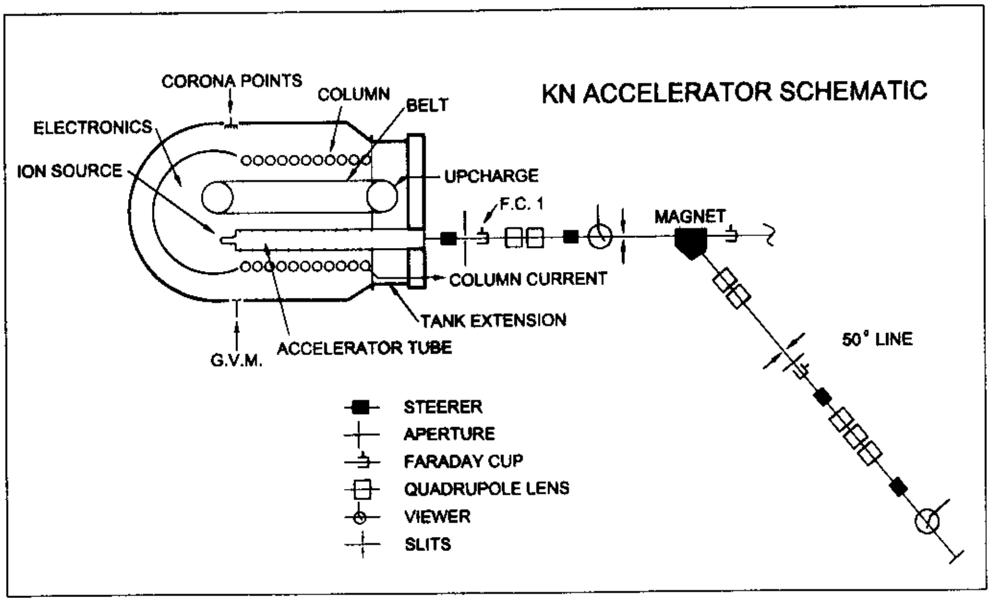

Figure1.

KN Schematic Drawing

1.4 Particles Accelerated

The following table lists the historical maximum currents and energies achieved during operation of the KN machine at McMaster University. Other ion beams could be generated in this source but this would require some development. Beams of particles heavier than helium would have lower currents.

Historical Data

Ion (+ve)	Maximum Analyzed Current	Maximum Energy
Protons	800 µamps	3.5 MeV
deuterons	200 µamps	3.0 MeV
Alphas	200 µamps	3.5 MeV
helium 3	50 µamps	1.2 MeV

1.5 Acceleration System

The DC terminal voltage in the KN accelerator is generated by use of a conventional belt charging system. The voltage is controlled by regulation of the upcharge voltage, the corona current and the flow of charge down the column through a resistor network which controls the voltage gradient.

Ion beams are generated in an r.f. ion source located in the terminal and are accelerated through a glass and metal, polyvinyl acetate sealed accelerator tube.

K.N. Accelerator Physical Specifications

Overall length of tank	3.6 m
Internal diameter	1.5 m
Normal operating pressure (SF_6)	up to 900 kPa
Maximum allowable working pressure	300 psig (~ 2100 kPa)
gross weight	~3 000 kg

3.3 Beam Transportation System

The only beamline currently in use is the 50° line. There is an analyzing magnet, three sets of quadrupole lenses and various apertures, scanners, slits and beam stops as shown in figure 1. The magnet also has outlets for beams at 90° and at 0°.

The entire beam line system is maintained at a vacuum of at least 1×10^{-6} Torr during operation. It is constructed mainly of aluminum and steel with some tantalum, rhenium and stainless steel in high temperature areas.

Software Engineering – Human/Computer Interface

1. **Molecular Beam Epitaxy** – Introduction & Description

2. **Historical Perspective** – i Complete Computer Control > Failure
ii Complete Manual Control > Successful, but cumbersome
iii Selected Computer Control > Ideal

3. **Variables:**

Variable Name	Possible Value	Type of Control
Indium Cell Temp	922.3 °C	Computer
Gallium Cell Temp	963.3 °C	Computer
Silicon Cell Temp	1194 °C	Computer
Beryllium Cell Temp	845 °C	Computer
Indium Cell Shutter	I/O	Computer
Gallium Cell Shutter	I/O	Computer
Silicon Cell Shutter	I/O	Computer
Beryllium Cell Shutter	I.O	Computer
Layer Growth Time	119"	Computer
Between Growth Time	Ramp & Go, or Pause	Computer / Operator
Interrupt	I/O	Operator
PH3 Flow Pressure	3.456 Torr	Operator
AsH3 Flow Pressure	8.421 Torr	Operator
Substrate Temperature/Ramp	470 °C	Operator

4. **Program Parameters**

Set by Program (Can not be Changed)	Set by Operator
Indium Ramp Rate > 35 /min	Gas Cracker Temperature
Gallium Ramp Rate > 35 /min	Substrate Ramp Rates
Silicon Ramp Rate > 60 /min	
Beryllium Ramp Rate > 60 /min	
Dwell Times after Ramp > 30"	

5. **Levels of Automation** > Manual
> Hardware Timing/Shutters but no Temp. Control
> Software Control of Timing/Shutters and Temp

6. **Code Generation** > Manual Sheet
> Computer Sheet (Uploaded to operating station)

MBE Sample Record

Sample # 3684
Researcher SVTA
Date Apr 30/02

Holder 2
Substrate n GaAs
Description

Desorb

Degas: n-type: 350/ m Si-type: 400/ m GaAs: 500/ m Other: / m

Gas Pbar Pcc

Thermal: Temperature Time

ECR:

P/[✓ As]	H2	Pcc	I1	I2	PF	PR	I(μa)	Tsub	Time	Notes
8.0	8.0	9.7-5	171	139	303	100		580	5'	2'A ✓

Notes:

Growth

Stage: Position: at 0 not +1mm

Layer	PH3	AsH3	In	Ga	Si	Be	Tsub	Time	Notes	RPM	Done
1		8.0		999.2		868	580	3'		20	✓
2	2.086	9.883		999.2		868	515	999"		20	✓
3	3.158	9.447									✓
4	3.915	9.022									✓
5	4.597	8.547									✓
6	5.079	8.148									✓
7	5.449	7.801									✓
8	5.797	7.441									✓
9	6.094	7.102									✓
10	6.347	6.788						999"			✓
11	6.347	6.788		999.2		868	515	2.5h	515 at end of layer		✓
12		8.0					580	1m	Anneal TR @ 40°/min		✓
13		9.0		999.2		802	515	10.8"	}16 x 		✓
14	6.347	6.788		999.2		802	515	10.8"			✓
15		9.0		999.2		925	515	18"	↖ switch to AsH_3 ASAP	20	✓
16									to flush P while Be↑		

Computer { (layers 13–15)

Notes:

MBE Sample Record

Sample # 3692
Researcher BR
Date May 6/2

Holder 2
Substrate ninpacro
Description candela

Desorb

Degas: n-type: 350/30'
Gas
Pbar
Pcc

Thermal: Temperature
Time

ECR:

~~P~~/As	H2	Pcc	I1	I2	PF	PR	I(μa)	Tsub	Time	Notes	
8.3	8.0	1.0-4	172	138	300	96		485	5'	2'A	✓

Notes:

Growth

Stage: Position:

Layer	PH3	AsH3	In	Ga	Si	Be	Tsub	Time	Notes	RPM	Done
	8.3		937.6		1243		470	1h		20	✓
[PAUSE]											✓
1	8.899	2.567	933.6 *	883.2 *	1195 *		470.0	4'48"		20	✓
[PAUSE]											
2	8.607	3.574	930.3 *	904.9 *	1195 *		470.0	3'		20	✓
[PAUSE]											
3	8.305	4.391	924.7 *	928.1 *			470.0	43.2"		20	✓
[LOOP BEGIN (x5, ATDs)]											
[PAUSE]	6.888	6.946									
4	~~6.907~~	~~6.920~~	*	*			470.0	19.8"	✓ ✓ ✓ ✓ ✓	20	✓
[PAUSE]											
5	8.305	4.391	*	*			470.0	43.2"	✓ ✓ ✓ ✓ ✓	20	✓
[LOOP END]											
[PAUSE]											
6	8.607	3.574	930.3 *	904.9 *			470.0	3'		20	✓
[PAUSE]											
7	8.899	2.567	933.6 *	883.2 *			470.0	4'48"	BRING UP Bc to 750	20	✓

Slight change QW only →

Notes: