HALF CENTURY OF ELECTRON MICROSCOPY IN SERBIA

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1. HISTORY

The first electron microscope was designed in 1931 by Ernest Ruska, as his diploma thesis at the Faculty of Engineering in Berlin; it was designed on the bases of Busch’s theory about electronic lens. (Fig.1). The microscope had magnification of only 17 times. In his doctoral dissertation in 1933 Ernest Ruska developed a new electron microscope with three electromagnetic lenses. The magnification was 12,000x, and resolution 50 nm, which is four times more than the resolution of the optical microscope (200nm). The replica of that microscope from 1933 was made by the constructor for the exhibition “300 years of microscope and biology cell” which took place in Berlin, in 1980.

For that epochal invention E.Ruska got half of the Nobel Prize for physics in 1986. The other half of the prize was divided by two scientists, Binning and Rohrer from Zurich, also for the epochal invention-tunneling of electrons, only 12 years after the scientific report on completely new type of microscopy with atomic resolution was published.

Binning and Rohrer brilliantly applied the so called tunnel effect, for which Gamov received the Nobel Prize for physics in 1929. Scanning tunnel microscope (STM) provides the atomic and submolecular resolution. The sample can be looked under vacuum, but also in air, gas or liquid environment. Prof. Djuro Koruga at the Technical Faculty in Belgrade has been a successful principal of the well-known school STM for years.

Soon the microscope triggered a series of inventions of new microscopes. It includes: the atomic force microscope (ASM), the magnetic force microscope MSM, the photon tunneling microscope (FTM or PTM), near field optical scanning microscope (BPOSM or NFOSM). The common characteristic of all these microscopes is the existence of probe, either electronic or photonic, which searches the sample, and the common name for these instruments is the microscopy of the scanning probe.

1 Academy of the medical science, SMS
The acoustic microscopy (AM) or the scanning acoustic microscopy (SAM) developed as a result of the research of substance by the use of sound (Z) or ultrasound (UZV). The whole system is easy to understand when you have in mind the fact that today the ultrasound diagnostics is used for determination of change in tissues and organs almost in all medical disciplines.

The contemporary transmission electron microscope, with the resolution less than two angstrom and magnification of 25 to 1,000,000 times, enables a detailed research of cell anatomy and determination of mutual relation between the cell structure and function and its organelle in all live systems. Depending on the type of interaction between electrons and the sample we use in the electron microscopy, there are conventional or transmission electron microscopy (TEM), scanning electron microscopy (SEM), S(T)EM, and electron microanalysis EMA, and thanks to the development of telecommunication technology telemicroscopy, remote control, service and navigation of the microscope were developed (P. Spasic).

The first Yugoslav model of the electron microscope is another result of Nedeljko Koshuta’s diploma thesis in 1954 in Zagreb. (J.B.Vukovic).

The golden age of the domestic constructions of electron microscopes started with Prof. Ales Strojnik at the School of electrical engineering in Ljubljana. On the basis of his microscope constructions, labeled LEM,” Iskra”–Kranj started producing commercial microscopes. One of these microscopes (Fig.2.) was used by academic Radivoj Milin at the Institute for histology of the Medical faculty in Novi Sad, and another by Petar Spasic at the Institute for pathology and forensic medicine at VMA (Fig.2). Soon the tough worldwide competition stopped the production of electron microscopes of many well-known firms (RCA, Siemens, and others), so our production stopped, too.

Five decades of electron microscopy in Serbia have been a very long and hard period full of laboratory openings, society establishments, personnel education, development and usage of complicated methods, preparation of samples for analysis by the electron microscope. All of this has been applied to everyday instruction, diagnostics and scientific research work. A great number of scientific work, M.Sc thesis and Ph.D thesis have been published. Our expert scientist has taken part many a time in Yugoslavian symposiums, scientific conferences of the society for electron microscopy in Serbia, European and international congresses. Their works have been cited in eminent books and well-known monographs.

In late fifties and early sixties of the last century Mira K Juric, nuclear physicist in Vinča, she practiced reading the tracks of the electrified particles in photoemulsion.

The establishment of the electron microscopy in Serbia is the establishment of the University laboratory for the electron microscopy in Belgrade, which is the main
laboratory in this field in Serbia. Thanks to scientific works, abstracts, bulletin and video recordings by Prof. Jovan B. Vukovic, my own archive, and also precious report about the functioning of the Laboratory for the electron microscopy at the University in Belgrade in period 1958-1978 by M.Sc Ranka Milinkovic, we are able to reconstruct realistically the development of this multidisciplinary scientific discipline in Serbia; Prof. Jovan B. Vukovic was ex director of this laboratory and president of the Society for microscopy and also restless author of chronicles on the electron microscopy in Serbia.

The Rector of University, Prof. Borivoj Blagojevic, Academic Panta Tutundzic at the Technological faculty, scientific advisor Dr. Blagoje Neskovic, physicist Prof. Vitomir Pavlovic and Prof. Slavoljub Harisijades initiated the work of the first electrostatic electron microscope in Serbia - ELMI-D2 produced by Carl Zeiss, Jena (Fig. 3), in 1956 in the halls which were given up to university by the Medicine faculty. The rector, Prof. Borivoj Blagojevic, although he had been involved in another scientific discipline, he soon realized the importance of forming a new field of scientific work, and he formed laboratory council whose first president was academic Panta Tutundzic. The first members of the council were: Prof. Vladimir Pantic, Prof. M. Sutic, Prof. B. Pavlovic, prof dr D. Rabrenovic, and Prof. Slavoljub Harisijades. The preliminary preparations had lasted about two years (1956-1957) before it started to work with full capacity in 1958.

The main mission of this laboratory was to upgrade the teaching and scientist research at the University, education of the personnel in this field and work on the scientific projects for needs of scientific institutions and economy, and cooperation with particular institutions in this country and abroad.

Prof. Slavoljub Harisijades, a microbiologist and virologist, was the first director of the Laboratory. He was succeeded by Prof. Jovan B. Vukovic, and Prof. Milorad Japundzic. A scientific advisor Blagoje Neskovic and M.Sc. in physics Ranka Milinkovic worked in this laboratory. Their work with the photography of a malignant cell at the ELMI was shown at the IV European congress in 1962, in Prag. (J.B.Vukovic).

The laboratory participated in the making of the first and the only one Yugoslav book on electron microscopy for master studies, which was published in Belgrade, (editor Prof. Vladimir Pantic) in 1962, and the authors were: A. Strojnik, B. Marinkovic, J. Vukovic, B. Navinsek, V. Pantic and N. Pipan.

Great contribution to the development of electron microscopy in Serbia was given by Academic Vladimir Pantic, who published his first work in this field. A major role of the establer of biophysical studies in Serbia, the high scientific advisor Dr Blagoje Nesakovic, in research of ultrastructure of tumor tissues is considerate.
In the process of establishment of Society for electron microscopy of Serbia in 1979, major roles had: Academic Vladimir Pantic, (the first president of the Society), Prof. Milorad Japundzic, Prof. Petar Spasic, Prof. Jovan B. Vukovic, Prof. Miodrag Pavicevic, Prof. Dojčin Dojčinov, Prof Vladimir Bumbasirevic. The members of presidency in period 1986-1988 were: V. Bumbasirevic, D.Gledic, I. Grzetic, Lj. Krstic, A. Laban, V. Lackovic, R.Milinkovic, Dj. Polic, B. Radmilovic, M. Sekulic, M. Hristic, A. Skaro Milic. However, due to the rapid development of science, technological innovation, and a large number of users, there was a need for a new contemporary microscope in university laboratory. Thanks to Prof. Vladimir Pantic, Prof. Ljubise Rakic and Prof. Vladimira Kanjuha’s devotion, financial resource both federal and republic and financial resource of the laboratory, the first-class electron microscope Philips 300 (Fig.4) was bought in 1970, with full equipment.

This main laboratory was opened for: institutes and clinics of Medical faculty, for all researchers of the University in Belgrade, for all other institutions out of university and for the economy throughout Serbia, but also scientist from other republics, because this laboratory had been the only one in Serbia for a long time.

According to the accurate evidence of the laboratory, before its integration with the Medical faculty, its services had been used by 324 collaborators from 15 faculties of the university of Belgrade and 121 collaborators of other institutions such as: Galenika, Institute for medical science, Institute Mihailo Pupin, Institute for blood transfusion and other institutions in Novi Sad, Nis, Sarajevo, Skopje, Prilep, Gnjilane, Vinca, Zemun, Maribor, Cacak, Loznic, and others, and more than 40000 photographs were made. Prof. Slavoljub Harisides was succeeded by Prof. Jovan B. Vukovic and Prof. Milorad Japundzic.

The University laboratory for electron microscopy has been an integral part of Institute for histology from 1991, which is equipped with the contemporary ultramicroscope, and recently with a new confocal microscope. Besides M.Sc Ranka Milinkovic, an important role for work of the laboratory, have dipl. Biol. Slobodanka Milicevic, Rajko Petrovic, Nadezda Cajlan, Milan Petric, Zlata Petrovic i Marija Mircetic, who retired in 2001. For the ULEM’s 20 th anniversary, which had been the only one of this kind in Serbia, the university presented the laboratory with the golden prize.

Later on, besides this main University laboratory for electron microscopy, in Serbia, was established another 17 laboratories in many institutions. One of the first in 1965 Institute of nuclear sciences Vinca got the microscope, TEM, JEOL, JEM 7, (Olga Nesic i Tomislav Nenadovic, Natasa Bibic, N. Kraljevic, V. Spasic, A. Mihajlovic), after that, Institute for biological science “’S. Stankovic” (V. Pantić, R. Vujčić, M. Hristić, D. Trajković), Military of academy (P. Spasic) and finally many faculties made their laboratories, Veterinary Faculty, Faculty of metallurgy and technology (M. Rogulic) and Medical faculty (B. Neskovic and D. Polic). Besides Belgrade the electron microscopy started to develop in Novi Sad (R. Milin) and Nis (D. Dojčinov, V. Savic).
Soon, many laboratories in different scientist institutions and faculties emerged such as: Faculty of electrotechnical, Institute for use radioisotope in agriculture, Industry of color and polish ‘‘Duga’’ industry for electron Zemun, Institute for vaccine and immunology (Torlak), Institute of technical military, Institute of mine (Trepca), Kosovo Mitrovica, Faculty of naturals since in Novi Sad.

20 years ago, Serbia had 26 electron microscopes of deferent brand, the most important were: Philips, JEOL, Siemens, C. Zeiss, Tesla, Iskra LEM, Isi, and ARL.

The founder of the laboratory for electron microscopy in The Military medical academy was Petar Spasic. Educated at Institute for pathology at the Medical faculty in Zagreb by Ivan Damjanov and at Royal Postgraduate Medical School – Hammersmith Hospital in London by prof. A. Waterson and K. Apostolova, and he was appointed for first director of the laboratory. The start was very hard. Institute for medical-technical research Torlak gave microscope LEM 4 Iskra Kranj as a present which was defunct, and eng. Joze Mulej from Ljubljana was invited to repair this microscope. In spite of the efforts of engineers and biologist Mira Belic from Novi Sad, microscope is had to be set apart. The purchase of new EM 201-C from Philips, and new LKB ultramicroton, in 1996, arrival of A Skaro-Milic at VMA in 1978, and the education of two technical personnel, enabled rapid development EM in VMA. The microscope was used for needs in nefropathology, (J. Dimitrijevic) virusology (S. Parabucki, Lj. Krstic, Vera Marinkovic, Nada Kuljic-Kapulica, Nada Draskovic and molecular biologist Zorica Lepsanovic), Institute for medical science Miodrag Colic, Institute for transfusionogy (Bela Balint), Stomatology (Slobodan Todorovic, Vojislav Rascanin, Besir Ljuskovic), dermatology (Djordje Karadaglic) and for all clinic of VMA. In the laboratory professional studies were attended by forty doctors from Belgrade, Nis, Novi Sad and from other cities, and they worked on ultrastructure research for realization of seven scientific projects, nine master and 17 doctors thesis. Besides the scientists from Medical military academy, actively participated the scientists from faculties for medical, veterinary and biology as and Institutes of science from Belgrade (Vinca, Torlak, VMI,) Institute of Technology of Nuclear and Other Mineral Raw Materials institute for medical science: Mirjana Pavlovic, Tijana Rajh, Aleksandra Ristic-Fira, Zorica Uzelac, Vesna Djurovic, Milan Cabric, Vladimir Bumbasirevic, Vesna Lackovic, Maja Nenadovic, Petar Milosavljevic, Ana Gligic, Branislava Keserovic, Vukoman Jokanovic, Predrag Jovanic, Miroslav Opric, from Novi Sad: Suzana Stajnic, Nevenka Stefanovic, Tamara Vukavic, from Zagreb: Duro Vranesic, Erika Arslanagic, Smiljana Kosanovic, from Nis: Djordje Penev. 

Besides the doctors and molecular biologists, dozens of laboratory technical personnel from Belgrade Zagreb, Novi Sad and Nis learned processing and preparation of sample for analysis by electron microscope, thanks to the exceptional devotion of technical
personnel Zuske Subotin, Miodrag Vitorovic, Tonka Ignjatovic, Olga Pavlovic and Bratislava Milenkovic. For the need of virusology at VMA and Torlak negative coloring of samples was used every day. In period of ten years more than one hundred scientific works were published. Society for electron microscopy in Serbia (P. Spasic) and society of Yugoslav’s Federation (J.B.Vukovic) in 1985 in VMA organized a conference with themes: Glikokalis in fetus (N Pipan), electron microanalysis of sulfide compound in geology (I Grzetic), Ultrastream pathology of nucleus (A Skaro-Milic) and ultrastructure of microtubule (V. Gal). The new transmission electron microscope Philips 208 S additionally equipped for morphotometric analysis of photos, was bought in 1997. prof. Petar Spasić and prof. A. Skaro Milic were succeeded by dipl biologist Dr. Goran Brajuskovic. In this laboratory there were all negatives and albums with about 20000 EM photographic, which is one of the richest and best, organized in Europe.

Faculty of mining and geology, thanks to the exceptional devotion of Prof Miodrag Pavicevic, opened the University laboratory for electron microanalysis ULEMA in 1978. Society for electron microscopy of Serbia and ULEMA, after the successful seminar “Application of energetic dispersive spectrometric X-rays in material and biology’s science” in march 1981, with about 300 participants, organized a very success international seminar: Electron microanalysis in technical and science, in December, that year. Lecturers were: Prof. M. Pavićević (ULEMA) Beograd, Prof. F. Vodopivec, (Met. Institute) Ljubljana, Prof. T. Nenadovic (Vinca) Beograd, DrK. V. Bassewitz (Chemisvhe Werke Hule), Marl, Prof. A Goresy (Max Planck Inst.), Hajdelberg, Prof. L. Rinderer (University de Lausanne), Lausanne Prof. E. Mooser (University de Lausanne), Lausanne, Prof. I. Borovski (AN SSSR), Černogolovka, Dr K. Juchli (ARL), En Valter, Dr J. Westernik (Philips) Endhoven) Holland. Lecture for 50 participants were in Centre SAVA and in Vinca.

Electron microscopy at biological faculty in Belgrade started working in the seventies of the last century, thanks to exceptional devotion and persistence of Dr Jelena Radovanovic and Mr Nada Serban. The preparation of samples and practical work on microscope took place at the Institute for biology science Sinisa Stankovic. Nada Serban spent six mounts in laboratory for biology cell in Ivry-sur-Seine with her mentor prof Pjer Favar and she was trained to prepare samples for scanning electron microscopy and citochrome. Work at the electron microscope is now in Institute for biology’s science Sinisa Stankovic.

In the eighties of the last century Faculty of biology bought Philips CM 12 electron microscope.

The nineties and the start of a new century was the period of intensive work on organization of the laboratory for preparation sample, education two profession collaborators for preparation material and work at electron microscope. The field of research had become broader, Dr Vesna Koko, Dr Aleksandra Korac, Dr Maja Cakic-Milosevic and Mr Mirela Ukropina joined research. Results of investigation were published in scientific work, which was part of doctors and masters thesis and diploma’s work. The laboratory for preparation sample and work at the electron microscope, are included in educative contents. The laboratory at the institute for oncology, thanks to knowledge and creativity of physicist Djoka Polic the director of the laboratory, became the centre for SEM in the
eighties of the last century, not only at the medical faculty, but also in throughout Serbia, the especially for biologist sample of the dermatology clinic.

The first Yugoslav symposium was in Ljubljana, in 1969. The plenary lectures were given by: A. Strojnik, V. Pantic, Z. Devide, B. Marinkovic, with 31 abstracts, unfortunately without printing material.
The first Balkan congress for electron microscopy (Prof. Lazar Jerkovic), was in Sarajevo 1974 with 41 reports.

The third Yugoslav symposium was in 1980 in Belgrade with 88 reports. This symposium organized by Society for electron microscopy of Serbia, as first registration society in Yugoslavia, formed with recognition in 1979. After this symposium society begin to form in all republics to later create made union Yugoslav. Society for electron microscopy.

The first scientific meeting of society for electron microscopy of Serbia was in Belgrade in 1982 with name ”Modern electron microscopy and microanalysis in biomedical research” (J Vukovic). At the meeting were presented only plenary lectures.

The forth Yugoslav symposium was in 1983 in Kranjska Gora (N. Pipan, M. Psenicnik, B. Drinovec) with 115 enclosures.
The fifth Yugoslav symposium was in 1986 in Plitvice (Z. Devide) with 116 enclosures.
The first congress of electron microscopy of Serbia was in Novi Sad in 1994.
The second congress of electron microscopy was in Belgrade in October 1996 also represented 40th of electron microscopy in Serbia.
The third congress of the New Serbian society for microscopy with international participation will be in 2007 in Belgrade.
The many members of Society for microscopy in Serbia were initiators and in organization of scientists meetings, courses for knowledge innovation, seminars, and symposiums, Yugoslav and Balcanic congress for electron microscopy. Large number of our researchers which were regular active participants at Europe of congresses for electron microscopy in Prague, Hague, Budapest, York.

I’ll be free to conclude, without exaggeration, that this discovery of the microscope is one of epochal events in history of the scientific research.

All our civilization, in the true sense of the word, is based on microscope. Thousand of articles which present our natural or artificially environment came under the microscope where is conducted to a composition, pure, large, dimension, shape, and uniformity and another characteristic of particles.
The microscope is instrument which assembles all of us, who use it, and the one who don’t use it not only today, society for electron microscopy in Serbia.

As well as everyone knows, top of development of the simple microscope was attain by Holland Anton van Leewenhoek in XIII century. From his 550 original mini-microscopes, only nine were kept. The best of them are finding in Utreht and the replicas which were created by him enable magnification to 500 times. A good replica of one of them got Society for electron microscopy in Serbia for ”30 years of the electron microscopy in Serbia” anniversary in SANU in 1986. In name of the Society for electron microscopy of Holland, present is delivered by W.C. de Bruin, from centre for analytical electron microscopy in Leiden, and resaved by Prof Jovan Vukovic,
president, one of the founders of the Society and author of chronicles on the electron microscopy in Serbia.
I am suggesting that this present take and hold a new administrative Serbian’s society for electron of microscopy, which I wish many successes in their work.

2. REFERENCES