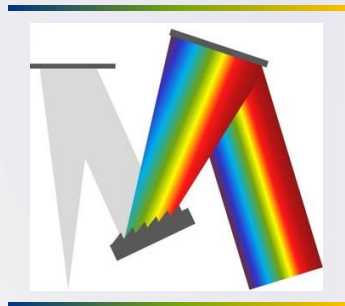




Exploration of photonics markets

MINIATURE, MICRO AND CHIP-SIZE SPECTROMETERS: TECHNOLOGIES, MARKET TRENDS AND CUSTOMERS NEEDS



While miniature and micro spectrometers achieve steady growth and find well established position on the market, disruptive chip-size technologies come up and elevate the role of spectroscopy to an entirely new level

Reference: EPIC Product Lunch

Authors: Jacek Kulakowski

October 2020



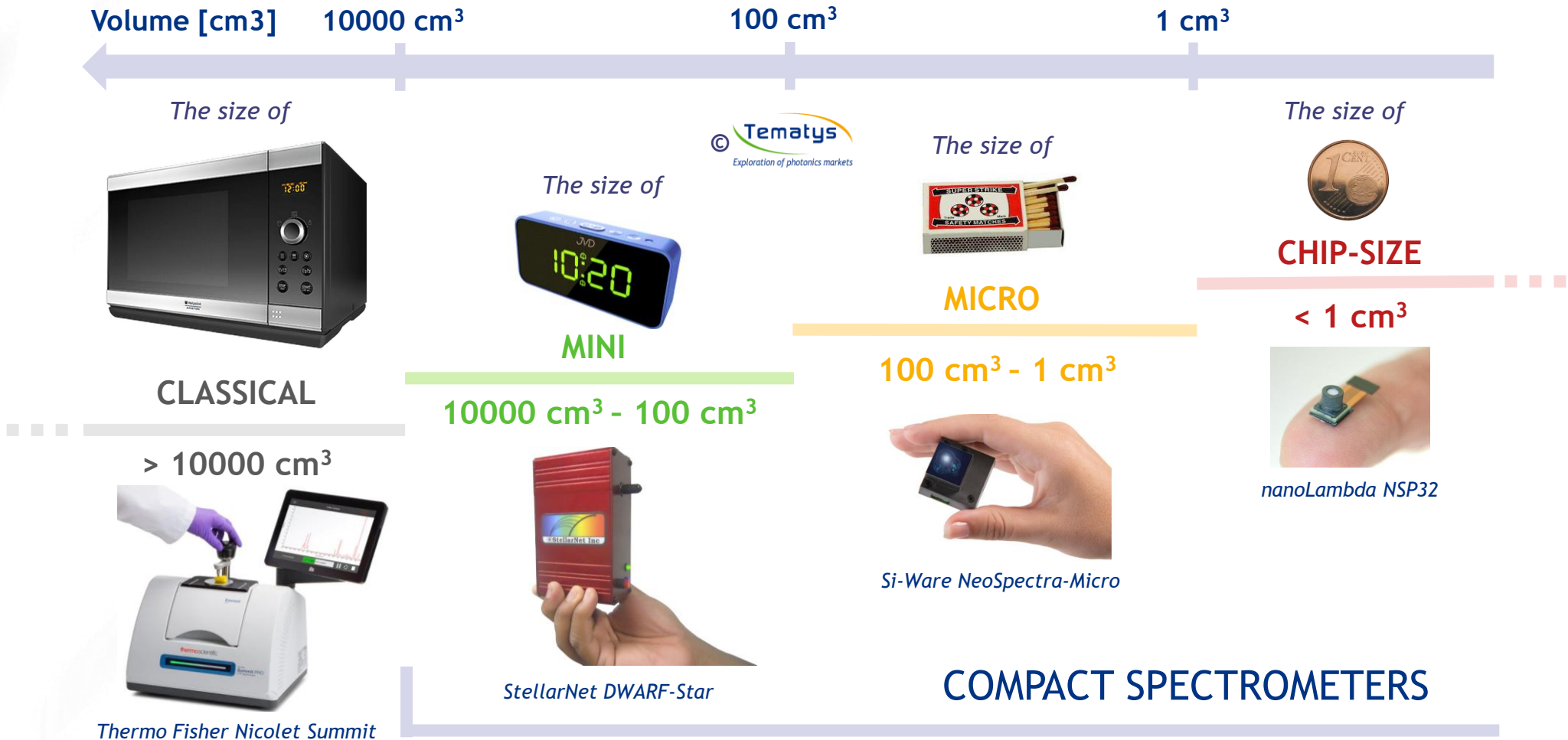
DISTINCTION BETWEEN DIFFERENT SPECTROMETERS SIZE

COMPACT SPECTROMETERS

MARKET STRUCTURE



Size limits for each class of spectrometers



<https://www.moneymuseum.com/en/coins?id=1995>
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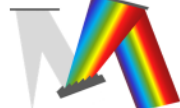
PRE-FLYER



Market & Technology Report

RELEASE SOON
PLEASE STAY TUNED

Miniature, Micro and Chip-size Spectrometers: Technologies, Markets Trends and Customers Needs



SPECTROSCOPY WILL BECOME A PART OF PEOPLE'S DAILY LIFE

REPORT OUTLINE

- Title: Miniature, Micro and Chip-size Spectrometers: Technologies, Markets Trends and Customers Needs
- 180+ slides (PDF)
- € 4 990 - Multi users license

KEY FEATURES OF THE REPORT

- Definition of miniature, micro and chip-size spectrometers
- Market revenue breakdown between classical and miniaturized spectrometers
- Unique compact spectrometers market forecast by applications 2020-2024
- Main OEM spectrometers manufacturers analysis
- Presentation of dominant market trends
- Description of strategies for spectrometers miniaturization
- Review of most promising applications

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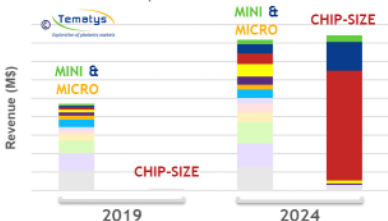
A **breakthrough moment** for spectral analysis is coming: while miniature and micro spectrometers achieve steady growth and find well established position on the market, the **disruptive chip-size technologies** come up and elevate the role of spectroscopy to a entirely new level. Now spectrometers can be available to **everyone**.

In the last few years optical spectroscopy became more popular due to the increasing need of in-line, on-field and Point-of-use measurements. The interest was confirmed by the high growth of **Compact Spectrometers Systems** market, which went from \$ 655M to \$ 922M in just three years (between 2016 and 2019). But emerging chip-size spectrometers are going to **fuel this growth even more**.

New type spectrometers can be as small as semiconductor wafers. Their ultra compact size (<1 cm²) allows to **integrate spectrometers with smartphones and other wearable devices**. The fastest growing applications will be therefore **biomedical and consumer**. The use of chip-size spectral sensors should reach >100M of pcs per year in 2024, with CAGR up to 140% (2020-2024) for some applications.

The report provides a comprehensive view on the **spectroscopy popularization** process. It describes the Compact Spectrometers market in detail, including breakdown into different spectrometers segments and applications (as below). It reaffirms and extends our predictions from the previous, 2016 TEMATYS report.

Forecast for spectrometers modules market



- Other applications
- Consumer
- Environment
- ASD (incl. Forensics)
- Industry - Food & Beverages
- Industry - Pharmaceuticals & Biotechnology
- Research
- Biomedical and Medical POC
- Agriculture
- Geology, mining and Oil & Gas
- Industry - Others (Automotive etc.)
- Industry - Chemistry
- Industry - Optical characterization



Market & Technology Report

DISRUPTIVE CHIP-SIZE TECHNOLOGIES PLAY THE DOMINANT ROLE IN THE GROWTH OF COMPACT SPECTROSCOPY



INFORMATION SOURCES

- Tematys' in-house knowledge of miniature, micro and chip-size spectrometers technologies and markets.
- Interviews with around 80 key manufacturers of miniature, micro and chip size spectrometers and end-users.
- Bibliographic research.
- Attendance in several international conferences in the field of spectrometers.

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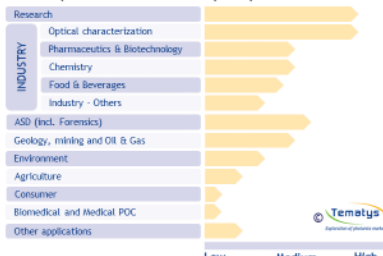
The first aim of development of compact spectrometers was to bring the lab measurements to the field or in the process line. By maintaining required performance level it was accomplished in many **industrial applications**: optical characterization, pharmaceuticals, biotechnology, chemistry etc. It was at the time when **miniature spectrometers** emerged (size < 10 000 cm²).

Few years later the same spectrometers opened also new applications where spectroscopy **had not been used before**: precision farming, recycling, process controlling, etc. The range of potential applications became vast.

The market started to be split into a **wide variety of niche adoptions**, each having its own requirements (performance, costs, design, operating conditions, etc.). This implied the development of products specifically to each segment.

At the same time **micro spectrometers** were presented (footprint between 10 000 cm² and 100 cm²), offering similar performance to miniature devices but in handheld, portable design. They enabled to develop systems for **application experts**.

Market penetration rates for compact spectrometers - 2019



It is still **research and industrial optical characterization** that possess the biggest market shares within compact spectrometers. However, the better knowledge of end-users needs results in improving **medium series applications** (agriculture, environment) and also in developing **new solutions for professionals** (like hair analyzers, textile identifiers, cannabis testers etc.).

A **turning point** for the market is coming. It is the arrival of **global leaders**, both in the role of manufacturers (Ami, Daram, VIAVI) and end-users (Apple, Samsung, Bosch, Henkel). Big players will drive the market towards **consumer and biomedical applications** (images enhancement, personal monitoring etc.).

The question is when the process of mass-market adoption will start and to what extent. The emergence of **chip-size spectrometers** (<1 cm²) allows to launch this process in a short-time perspective.

In this report we provide a detailed analysis of **most promising markets** and describe the **end-users needs** as well as **remaining challenges** for widespread use of compact spectrometers.



Market & Technology Report

ARE THE ACQUISITIONS GOING TO CONSOLIDATE THE MARKET?



Still, most companies of the compact spectrometers sub-systems market (90%) are autonomous entities. However, the **trend of consolidation** is more and more evident.

Since 2019 due to the acquisitions done by Wynnec Group and Metrohm (also earlier Halma) only three companies account for a 1/3 part of the market. Together with other five main companies they account for 86% of market revenue.

INNOVATIVE SOLUTIONS

To reach new applications, technological breakthrough is necessary. That is why miniaturization of spectrometers exploits **new designs and innovative solutions**.

Recent progress in compact spectrometers technology follow this path and takes an advantage of micro-technologies such as **MEMS and MOEMS**. This reduces the **cost and size** of spectrometers while allowing good performance and large production.

KEY IMPORTANCE OF MODERN ALGORITHMS

Data analysis is becoming crucial for developing new spectrometer applications, especially for those based on chip-size spectrometers.

Global IT environment helps in the progress - development of Cloud Solutions, Big Data, Machine Learning, Artificial Intelligence is very extensive. There is a lot of funding for Machine Learning companies (\$ 16.5B in 2019 globally, driven by 698 deals).

The gap between the biggest entities and others competitors is **widening** and it is also harder to enter the market. Older companies are trusted, can provide many references and offer mature products.

It is still an open question who is going to **catch the value** on the current compact spectrometer sub-systems market out of the main players. This report analyzes opportunities and challenges to achieve that.

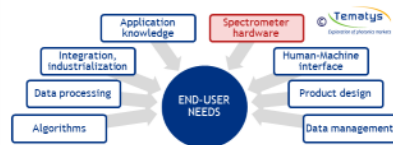
In case of disruptive, chip-size spectrometers, the dominant technologies are: **ultra-compact gratings, Fabry-Pérot multispectral filters, plasmonic filters, organic semiconductors, photonic crystals**.

This study consists a detailed description of all key technologies of the compact spectrometers market with an additional explanation of potential opportunities and challenges in their development.

Currently algorithms are the **key elements** of the spectroscopic system - even if there is a lot of stray light in the spectrometer one can correct it with proper data processing. Modern algorithms allow to **reduce the cost** of extracting useful information from the spectra. This helps to bring spectroscopy out of the lab.

The report helps to understand the role of modern algorithms in compact spectroscopy.

Essential components of compact spectroscopic system



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