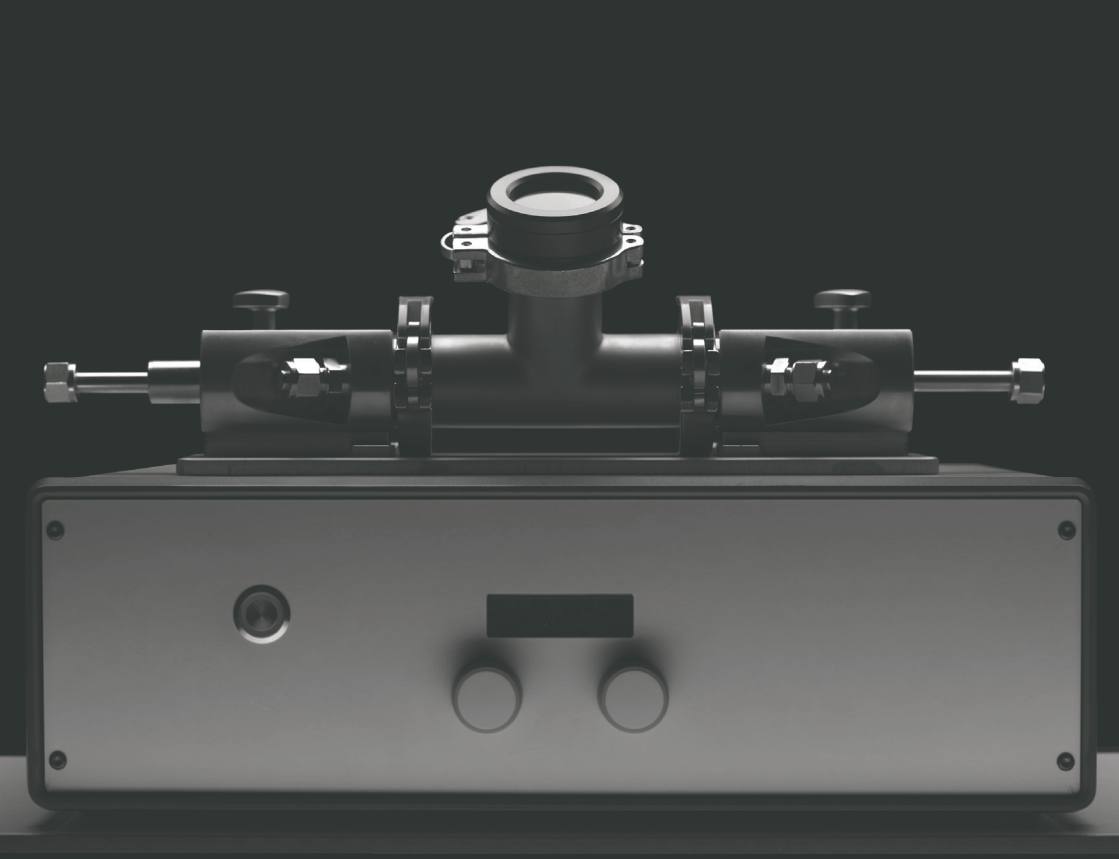


Automated nanoparticle production

VSP-G1 NANOPARTICLE GENERATOR

vsparticle

At VSPARTICLE we believe that there is a whole new world of possibilities for materials at the nanoscale.

At VSPARTICLE we make the manufacturing of nanostructured materials as easy as pushing a button. We provide research and industry with the tools to rapidly advance the field of nanotechnology and thereby drastically reduce the development time of new materials and products.

Create the future at the push of a button

vsparticle

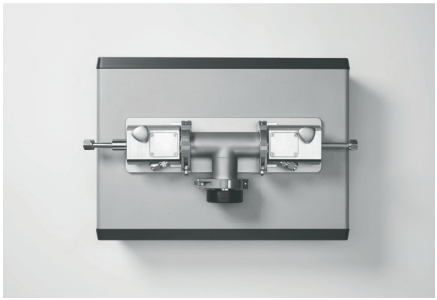
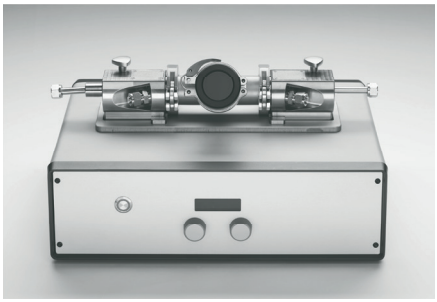
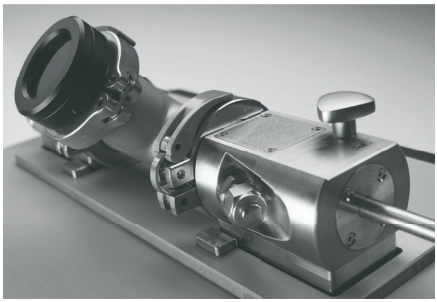
Easier, faster and reproducible generation of nanoparticles

The current methods to generate nanoparticles are complex and time consuming. Furthermore, the lack of material versatility is an issue. With the VSP-G1 researchers can reduce months of work to just a matter of hours or days.

- **Easy**: The VSP-G1 is controlled by just three buttons. One serves as on/off switch and emergency stop, the other two are used to alter the particle size and production rate. The VSP-G1 is operated at room temperature and standard pressure.
- **Reproducible**: The VSP-G1 has a stable and reproducible output. With quick iterations you can find your ideal settings and there is nothing that stops you from reproducing it the next day.
- **Fast:** Combining the VSP-G1 with accessories enables you to prepare your nanoparticle sample in a single step. Just load your sample in the sample holder accessory, start the gas flow and press the spark-button of the VSP-G1.
- **Safe**: One of the key challenges in the development of the VSP-G1 was to enable flexibility and at the same time guaranteeing safe handling of nanoparticles. The VSP-G1 has been designed as a closed system and by making it possible to unmount the reactor chamber, it can be cleaned easily and safely in a fume hood.

Designed for desktop use

THE VSP-G1 FITS ANY LAB TABLE AND CAN OPERATE 24/7

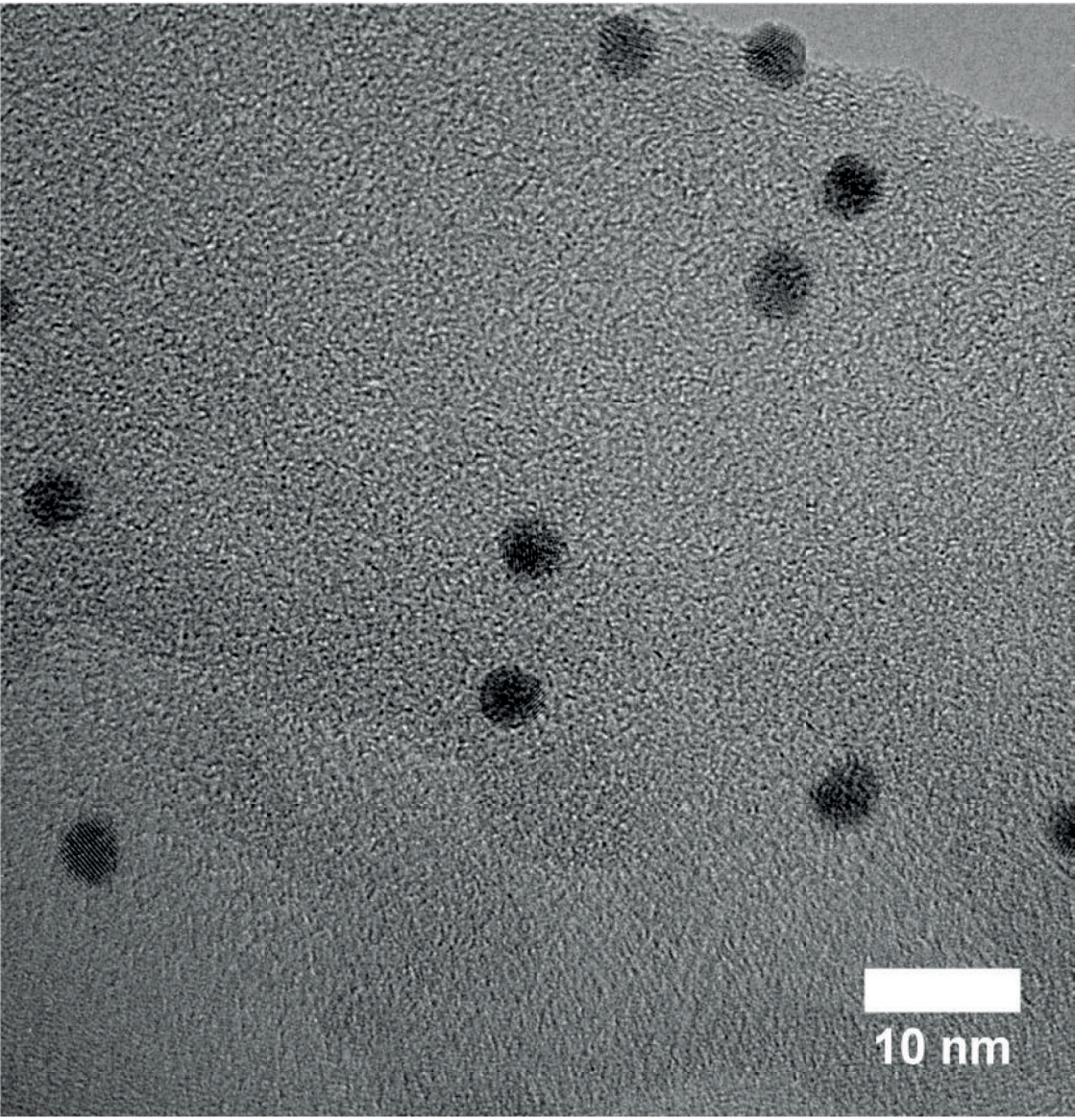
The VSP-G1 nanoparticle generator provides you with the possibility to perform ground-breaking research by automating the production of nanoparticles. It allows you to move through the research cycle quickly, fast forwarding from hypothesis to success!

Best-in-class user experience

GENERATE NANOPARTICLES WITH THE PUSH OF A BUTTON

The VSP-G1:

- is intuitive for scientists and students
- allows for quick iterations to speed up research
- minimizes setup time
- logs settings via the RS232 port on the back
- fits your lab-table and fume hood

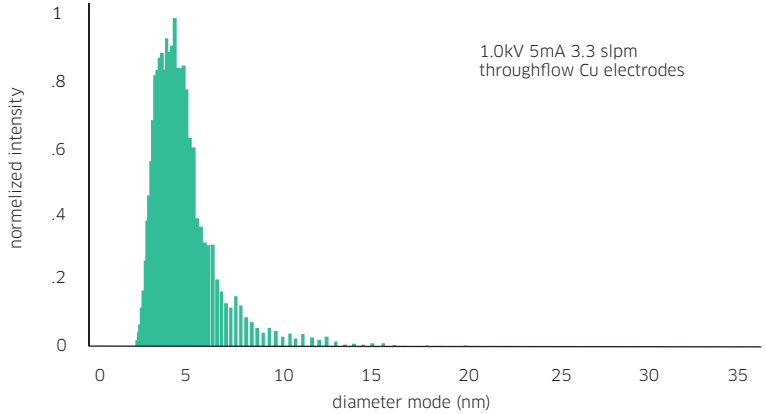


TEM image with single gold spherical particles which are well dispersed and generated with the VSP-G1.

Very small particles at high concentrations

OUTPUT DISTRIBUTION OF PARTICLES BETWEEN 0-20 NM

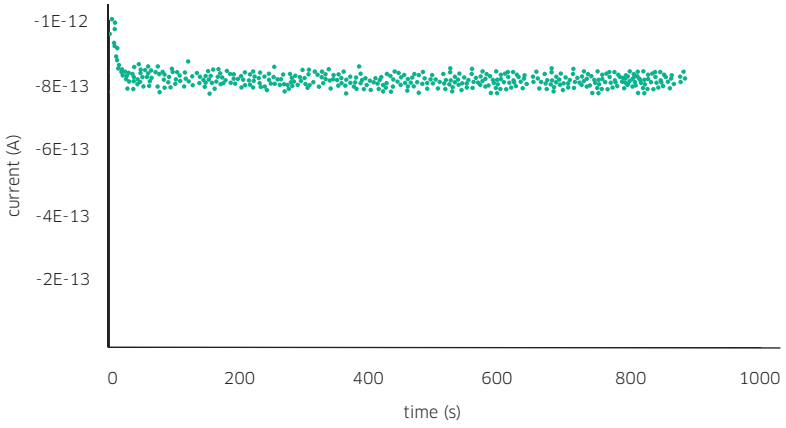
Making very small particles at high concentrations is one of the most challenging tasks in aerosol research and material science. The VSP-G1 delivers high output of very small particles, starting from atomic clusters. The output shows a nice lognormal distribution.



Ultra-stable and reliable aerosol output

<2% STANDARD DEVIATION IN LONG-TERM EXPERIMENTS

After finding the equilibrium state of the desired concentration and particle size, the source has a highly reliable production output, with a standard deviation of <2%. This will help your research by offering reproducible results over long term experiments.



Material versatility

MIX AND MATCH YOUR METALS

All solid (semi)conductive materials that can be processed into electrodes can be used in this device. This allows for the creation of particles of bi-metals, nano-alloys or materials that are immiscible in bulk state. To make your life easy we provide standard electrodes, contact us for available stock.

It is possible to use elemental electrodes and alloyed electrodes. Contact us to find out about possibilities of mixing elemental electrodes and compacted alloys.

COMPATIBLE ELEMENTS

Elements highlighted in green are compatible with spark ablation. Elements in green may be used in the spark ablation process (e.g. as carrier gas or modifier). Information is available for elements in black.

1 H Hydrogen 1.01																	2 He Helium 4
3 Li Lithium 6.94	4 Be Beryllium 0.01											5 B Boron 10.81	6 C Carbon 12.01	7 N Nitrogen 14.01	8 O Oxygen 16	9 F Fluorine 19	10 Ne Neon 20.18
11 Na Sodium 22.99	12 Mg Magnesi.. 24.3											13 Al Aluminium 26.98	14 Si Silicon.. 28.09	15 P Phospho.. 30.97	16 S Sulfur 32.06	17 Cl Chlorine 35.45	18 Ar Argon 39.1
19 K Potassium 39.95	20 Ca Calcium 40.08	21 Sc Scandium 44.96	22 Ti Titanium 47.87	23 V Vanadium 50.94	24 Cr Chromium 52	25 Mn Mangane 54.94	26 Fe Iron 55.34	27 Co Cobalt 58.69	28 Ni Nickel 58.93	29 Cu Copper 63.55	30 Zn Zinc 65.39	31 Ca Callium 69/72	32 Ge Germani.. 72.64	33 As Arsenic 74.92	34 Se Selenium 78.96	35 Br Bromine 79.9	36 Kr Krypton 83.8
37 Rb Rubidium 85.47	38 Sr Strontium 87.52	39 Y Yttrium 88.91	40 Zr Zirconium 91.22	41 Nb Niobium 92.91	2 Mo Molybde 95.94	43 Tc Techneti.. 98	44 Ru Rutheniu.. 101.07	45 Rh Rhodium 102.91	46 Pd Palladium 106.42	47 Ag Silver 107.87	48 Cd Cadmium 112.41	49 In Indium 114.82	50 Sn Tin 118.71	51 Sb Antimony 121.76	52 Te Tellurium 126.9	53 I Iodine 127.6	54 Xe Xenon 131.29
55 Cs Cesium 132.91	56 Ba Barium 137.33	57-71 Lanthan..	72 Hf Hafnium 178.49	73 Ta Tantalum 180.95	24 W Tungsten 183.84	25 Re Rhenium 186.21	26 Os Osmium 190.23	27 Ir Iridium 192.22	28 Pt Platinum 195.08	29 Au Gold 190.97	30 Hg Mercury 200.59	31 Tl Thallium 204.38	32 Pb Lead 207.2	33 Bi Bismuth 208.98	34 Po Polonium 209	35 At Astatine 210	36 Rn Radon 222
87 Fr Francium 223	88 Ra Radium 226	89-103 Actinoids	104 Rf Rutherfo 262	105 Db Dubnium 262	106 Sg Seaborgi.. 264	107 Bh Bohrium 266	108 Hs Hassium 268	109 Mt Meitneri.. 272	110 Ds Darmsta.. 277	111 Rg Rontgium 0	112 Cn Copernic.. 0	113 Nh Nihonium 0	114 Fl Flerovium 0	115 Mc Moscovi.. 0	116 Lv Livermor.. 0	117 Ts Tennesine 0	118 Og Oganess 0

Lanthanoids	57 La Lanthan.. 138.91	58 Ce Cerium 140.12	59 Pr Praseod.. 140.91	60 Nd Neodymi.. 144.24	61 Pm Promethi.. 145	62 Sm Samarium 150.36	63 Eu Europium 151.96	64 Gd Gadolini.. 157.25	65 Tb Terbium 158.93	66 Dy Dysprosi.. 162.5	67 Ho Holmium 164.93	68 Er Erbium 167.26	69 Tm Thulium 168.93	70 Yb Ytterbium 173.04	71 Lu Lutetium 174.97
Actanoids	89 Ac Actinium 227	90 Th Thorium 231.04	91 Pa Protactin.. 232.04	92 U Uranium 237	93 Np Neptuniu.. 238.03	94 Pu Plutonium 243	95 Am Americiu.. 244	96 Cm Curium 247	97 Bk Berkelium 247	98 Cf Californi.. 251	99 Es Einsteini.. 252	100 Fm Fermium 257	101 Md Mendele.. 258	102 No Nobelium 259	103 Lr Lawrenci.. 251

For more information about these elements, go to vsparticle.com/nanoparticles

Control of particle size

CONTROLLING PARTICLE SIZE WITH GAS FLOW AND SPARK ENERGY

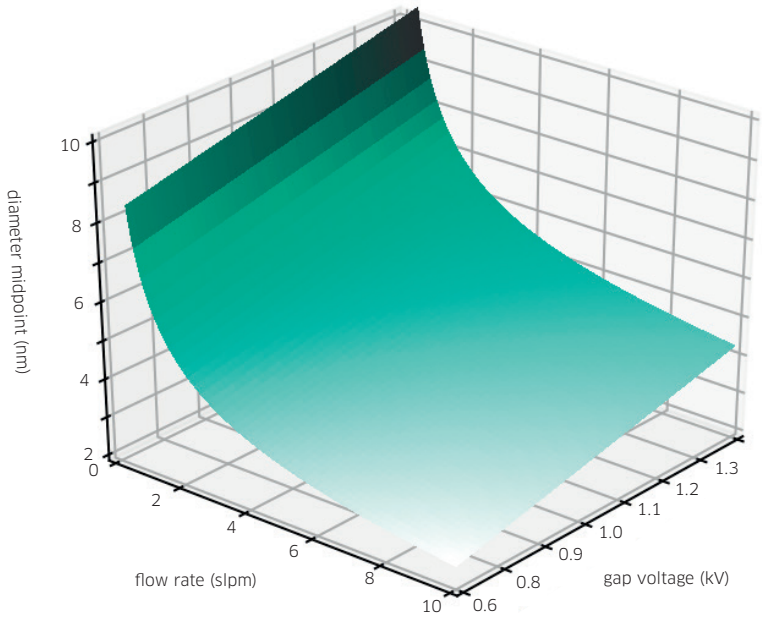
The diameter midpoint of the size distribution can be adjusted by controlling flow rate and gap voltage. The graph below shows the correlation between the gas flow, gap voltage and the main mode with the G1 at a fixed distance of the accessory (30 cm) in crossflow-mode. Larger particles can be obtained by heating or by increasing the distance to the accessory.

Control size by adjusting:

Gas flow rate

Gap voltage

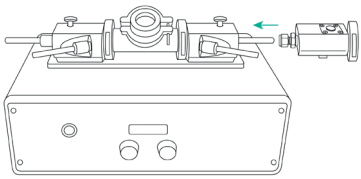
Tube length



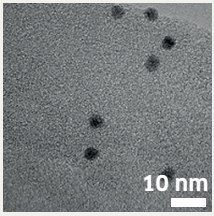
Immobilizing the particles

DEPOSITING THE NANOPARTICLES ON YOUR SUBSTRATE

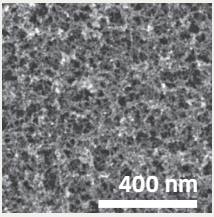
The VSP-G1 outputs a clean gas stream filled with pure nanoparticles, ideal for aerosol and toxicity related research. Combining the VSP-G1 with one of the accessories enables you to get the particles out of the gas and onto your substrate for material research.



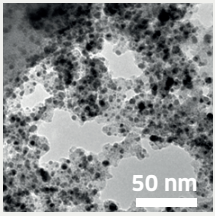
diffusion



impaction



filtration



	diffusion	impaction	filtration
Materials	Metals, Oxides, Alloys, Semi-conductors, Carbon	Metals, Oxides, Alloys, Semi-conductors, Carbon	Metals, Oxides, Alloys, Semi-conductors, Carbon
Works with	TEM grids, in-situ TEM/MEMS, SiOx	TEM grids, in-situ TEM/MEMS, SiOx	Filters, active carbon membranes, nanospun wires
Max sample size	1 cm2	1 mm2	Max filter diameter 47mm
Applications	In-situ TEM catalyst research, materials science	Catalysis, in-situ TEM, sensors, batteries	Catalysis, batteries, filter testing
Particle size	0 - 10 nm	Primary particle size 0 - 10 nm	0 - 10 nm
Sample prep time	5 - 15 min	1 - 5 min	1 - 5 min

Flexible offerings

CHOOSE THE OPTION THAT SUITS YOU

The VSPARTICLE sales team is always prepared to think along which option suits you best:

- Buying the VSP-G1 nanoparticle generator
- Leasing the VSP-G1 nanoparticle generator
- Renting the vsparticle lab
- Nanoparticle samples of the material of your choice
- Support from our research team

More remarkable product features

Safe-by-design: The VSP-G1 is developed with safety in mind, as a closed system. The modular reactor head can be unmounted and cleaned easily and safely in a fume hood. The VSP-G1 is compliant with IEC 61010-1 norms for laboratory equipment.

No chemicals needed: The spark ablation process used in the VSP-G1 is a purely physical process that only requires electricity, a carrier gas and electrode material to produce clean nanoparticles. The produced nanoparticles can be directly incorporated into the next process step or applied in a product by, for example, impaction, electrostatic precipitation or filtering.

In your own lab or with vsparticle support: If you wish to set the VSP-G1 up in your own lab, you can opt for either buying or leasing. It is also possible to work in our lab or let vsparticle provide you with some test samples. Just contact our sales team to see which option fits your situation and research best.

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Tech Specs

Power	110-240V AC
Dimensions	Casing ca. 52x30x20cm
Reactor added height	ca. 10cm
Weight	19kg
Gas inlet/outlet	10mm tubes (with Swagelok connectors)
Display	16x2 characters
Digital output	RS232

Relevant literature

- **Generation of nanoparticles by spark discharge**, Tabrizi, N. S. et al., Journal of Nanoparticle Research (2009), doi: 10.1007/s11051-008-9407-y
- **New developments in spark production of nanoparticles Pfeiffer**, T. V. et al., Advanced Powder Technology (2014), doi: 10.1016/j.apt.2013.12.005
- **Atomic Cluster Generation with an Atmospheric Pressure Spark Discharge Generator**, Maisser, A. et al., Aerosol Science and Technology (2015), doi: 10.1080/02786826.2015.1080812

Operating window

Flow rate	1-30 L/min
Gas Supported	Ar or N_2 (recommended purity 5.0)
Unsupported	He, Ne, Xe, Kr Contact VSPARTICLE for use of reactive gases such as air, H_2.
Electrode material	Supplied with Cu electrodes but most semiconductors can be ordered
Primary particle size	1 atom to 20 nm
Ablation rate	~0.01-100 mg/h (material dependent)
Typical particle concentration	10^8-10^{11} cm^{-3} (material dependent)

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